Investing in Regenerative Agriculture

Reflections from the Past Decade

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White Paper

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Executive summary

This paper sets out the investment and environmental case for regenerative agriculture, while also highlighting the risks and challenges. It is an update to an influential white paper that we first published in 2016. It draws on the latest research, as well as SLM Partners' experience making investments in this theme for more than a decade.

Defining regenerative agriculture

We adopt a broad definition of regenerative agriculture: the growing of nutritious food and other products in a way that enhances soil health, climate stability and ecosystem functionality, while being economically sustainable for the farmer. To understand regenerative agriculture, it is helpful to differentiate between principles, farming practices, agricultural systems and outcomes. Ultimately, we know regenerative agriculture by its outcomes – its environmental, social and economic impacts. The practices and systems that farmers use will vary depending on local context, although they are underpinned by common principles that focus on soil health and emphasise biology over chemical inputs.

Positive impacts

Regenerative agriculture can deliver important environmental and social outcomes, namely:

- Improving soil health
- Addressing climate change
- Enhancing biodiversity
- Improving water quality
- Growing higher quality, nutritious food

Synthesising the latest academic research, this paper shows how regenerative agriculture can address many of the negative social and environmental impacts associated with our food systems, while restoring the productive capacity of ecosystems and growing better food.

Economic returns

Regenerative agriculture can be more profitable and deliver superior risk-adjusted financial returns to farmers and investors – we call this the "Regenerative Edge". These superior returns will come from one or more levers: higher yields, lower operating costs, higher output prices, new environmental payments (such as carbon) or more stable operating results (i.e. resilience). A number of recent studies have assessed the overall profitability of regenerative agriculture at the farm level, with positive results.

How to invest

Investors can support the transition to regenerative agriculture by investing along the food value chain. They can have the most direct impact by investing in farmland as part of a real asset strategy. Investor allocations to farmland are increasing because of strong historical performance, lack of correlation with other assets classes, and resilience to financial market downturns and inflation. But investing in farmland that is managed regeneratively has added benefits and can provide a higher return for investors (Alpha) – in the right context, it can add 1-3% to an annualised internal rate of return.

Nonetheless, there are challenges to investing in regenerative farmland: a scarcity of regenerative farmers, scale limitations, highly priced land assets and tough farming economics. Successful strategies require a realistic attitude to rates of return and scale, rigorous analysis of market dynamics and careful selection of farmer partners – the scarcest commodity of all.

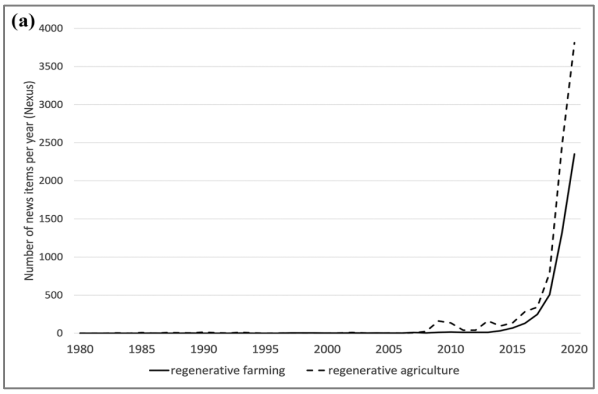
If these pieces are in place, we believe that regenerative agriculture can be a compelling investment opportunity.

Introduction

In 2016, SLM Partners published a white paper called *The Investment Case for Ecological Farming*. It set out the problems of conventional agriculture, showed how ecological and regenerative farming systems could deliver important environmental and social benefits, and explained why this was an attractive investment opportunity. Our goal was to provide a primer for those coming to the theme for the first time. We have met many people who have used it in this way, and it has been a pleasant surprise to see this paper still referenced today.

But it is time for an update – a lot has happened over the last 8 years. Since then, regenerative agriculture has become a buzzword for food activists, climate campaigners and impact investors. Food companies are embracing regenerative agriculture as the solution to supply chain sustainability: companies with combined annual revenues of over $1 trillion are now using the term.[1] Investment managers are rebranding and launching new strategies with regenerative agriculture front and centre. At the same time, we at SLM Partners have gained a lot more experience in the realities of investing in regenerative agriculture through our work in Australia, the USA and Europe.

Occurrence of Regenerative Agriculture or Regenerative Farming in news items



Source: K.E. Giller et al, 'Regenerative agriculture: an agronomic perspective', *Outlook on Agriculture*, 50 (1) (2021)

Regenerative agriculture may be at the peak of a hype cycle right now. New entrants, often with little farming experience, can get carried away after seeing an inspiring documentary or reading a few books. To them, the answer is obvious, the investment opportunity is massive, and traditional farmers who don't get on board are dumb. They sometimes exaggerate the environmental and economic potential of this movement. This 'boosterism' risks creating unrealistic expectations if investors are promised private equity or venture-type returns from investing in farmland – this is hard to achieve no matter how regenerative you are – or told that they can put billions of dollars to work quickly.

On the other hand, we see established farmland investment managers racing to wrap their activities in the mantle of regenerative agriculture. To them, the farming practices they use have always been sustainable, so there is no need to fundamentally change the way the way they operate. Instead, they make a greater effort to collect data on environmental impacts and present this through glossy new reports, often put together by a newly-hired sustainability officer. There is a risk of 'greenwashing' that may leave investors confused as they try to separate strategies that deliver real change from those that perpetuate business as usual.

The emergence of 'Natural Capital' as a branch of impact investing of almost limitless malleability provides another useful label for managers to shelter under. Investors are making commitments on climate change and biodiversity and see regenerative agriculture as a way to deliver on these impact goals. It is true that agriculture (and its sister forestry) relies more directly on the natural environment than most other economic activity. But not all investment in agriculture (or forestry) enhances natural capital. In fact, conventional agriculture is linked to many negative environmental impacts. Investors need to look beyond the labels and understand the real impacts of the systems they invest in.

At the same time, more capital is flowing into agriculture than ever before because of broader financial trends. Investors are increasingly attracted to a natural real asset such as farmland because it can deliver regular income yields, capital appreciation, inflation protection, lack of correlation with other asset classes, and historically strong returns with low volatility. In addition, there has been a wave of interest in Ag Tech, rippling out from the tide of technology investing.

The potential of regenerative agriculture is real. And we believe it can represent a compelling investment opportunity. But lots of elements need to be in place to make this happen and investors must understand the risk / return profile, as with any investment. Through this white paper, we hope to contribute towards a better understand of the opportunity and the challenges. Our paper is aimed at pensions, insurers, family offices, and wealth managers who are exploring this theme and considering making an allocation to farmland and regenerative agriculture.

This paper should be read in conjunction with our 2016 publication. It will not repeat the research and arguments made in that publication, but will focus on new research that has appeared since 2016 – thankfully, research on this topic has multiplied since then. It also draws on our experiences making investments and working with farmers in Australia, the USA and Europe for more than a decade. We have made mistakes, had some successes and increased our knowledge immeasurably during this time. This paper tries to answer some of the questions we hear most frequently from investors who are studying this theme. It also tries to clear up some common misperceptions and confusions.

The first section explores what regenerative agriculture is, and tries to separate it from conventional agriculture, by looking at it in terms of principles, practices, systems and outcomes. The second section sketches out the positive environmental and social benefits associated with regenerative agriculture. The third section analyses the economic case for regenerative agriculture and shows how, in certain circumstances, it can deliver superior financial returns. The fourth section discusses how to invest in this theme, while pointing out some of the pitfalls.

We hope to make a useful contribution that will allow more informed investment in better food systems.

About SLM Partners

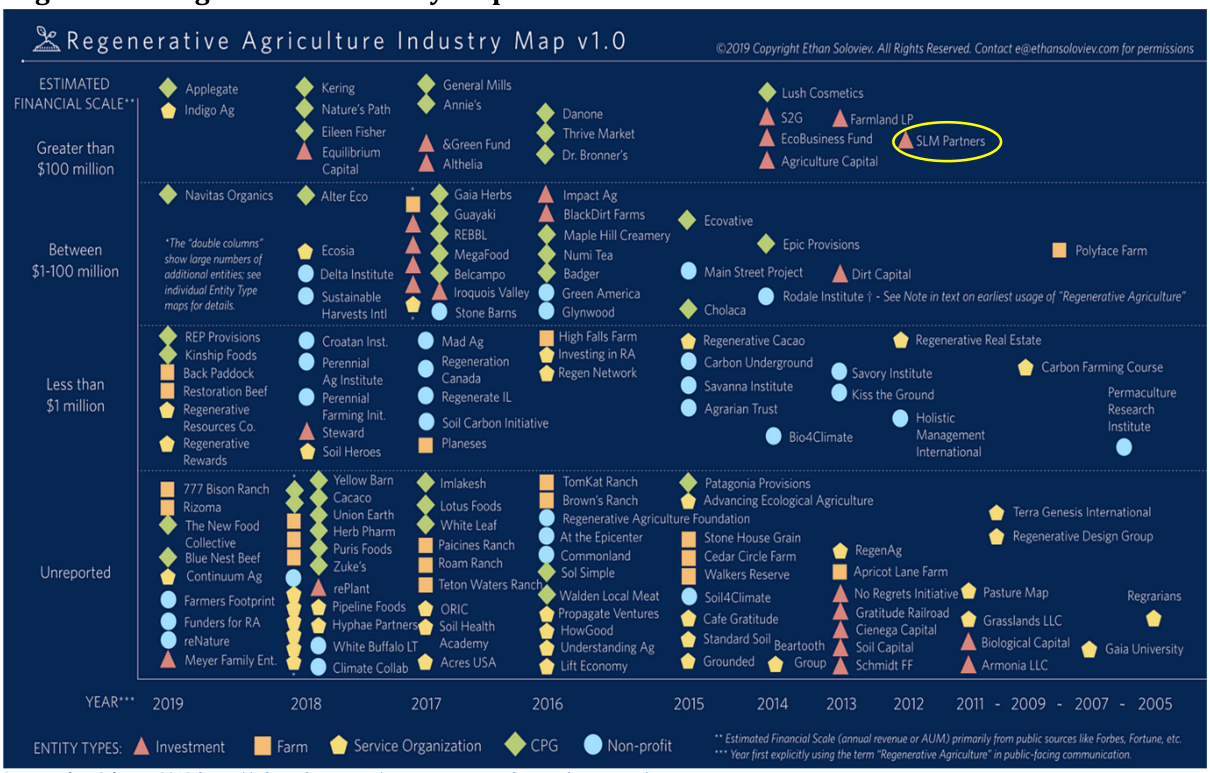
SLM Partners is an asset manager that uses investment capital to scale up regenerative agriculture and forestry. We invest in real assets, especially land, and partner with skilled farmers and foresters to bring that land under ecological management. We provide investors with the financial benefits of natural real assets while helping deliver on their sustainability goals. All our strategies seek to deliver measurable positive impacts on soil health, biodiversity, and carbon storage.

SLM Partners invests in annual crops, permanent crops, pasture-raised livestock and forestry across the USA, Europe and Australia.

We manage a number of funds and separate accounts on behalf of pension funds, insurance companies and family offices. As of 31 Dec 2023, we had $580 million in assets under management.

Founded in 2009, SLM Partners is one of the longest-established managers with a focus on regenerative agriculture. Proof of this can be found in the *Regenerative Agriculture Industry Map v1.0* reproduced below. SLM Partners was the first investment group with reported financial assets to use the term 'regenerative agriculture'. This dates back to 2012 when we launched our first fund to invest in regenerative grazing in Australia.

Regenerative agriculture industry map v10



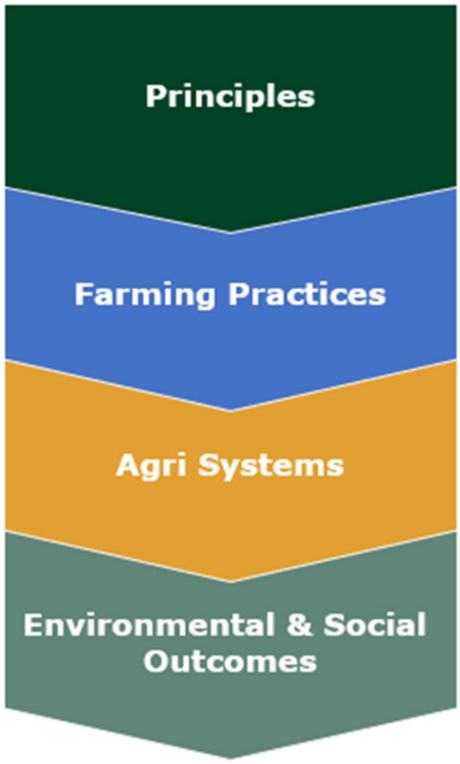
Source: Ethan Soloviev, 2019. https://ethansoloviev.com/regenerative-agriculture-industry-map/

What is regenerative agriculture?

For regenerative agriculture to have meaning, it must be distinguishable from conventional, mainstream agriculture. Yet, there is no universally-accepted definition of what regenerative agriculture is. Some people define it in very reductive terms: for some American advocates it means no-till farming with cover crops and little else. Others stretch it so far that it could be applied to any farming system, which tends to devalue the concept and create scope for greenwashing. The difficulty is that regenerative agriculture can look very different depending on the crop or livestock grown and the local context (i.e. the ecosystem and markets). For example, its application will look very different on a grain farm in the US Midwest, a pastoral cattle station in Australia, an almond orchard in California, and a smallholder plot in tropical Africa, although it is just as relevant in all these contexts.

We adopt a broad definition of regenerative agriculture: the growing of nutritious food and other products in a way that enhances soil health, climate stability and ecosystem functionality, while being economically sustainable for the farmer. To understand its nuances, it is helpful to differentiate between the principles that lie behind regenerative agriculture, the farming practices through which it is implemented, the agricultural systems that are most viable, and the outcomes that can be measured. Sometimes these concepts get muddled up, which is one reason for disagreement over definitions.

Understanding regenerative agriculture



Principles

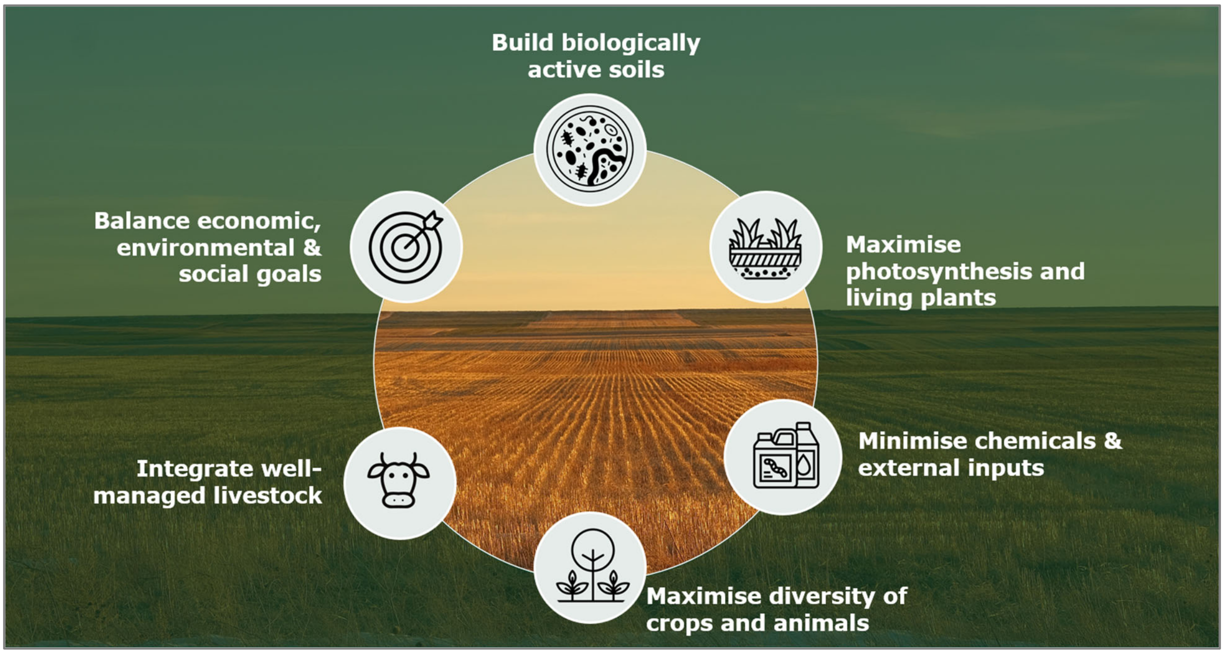
Conventional agriculture is characterised by a limited range of crops or animals (specialisation), heavy reliance on synthetic inputs (fertilisers and pesticides), soil disturbance by powerful machinery, and a focus on achieving maximum yields at scale.[2] This often degrades soil structure and soil biology, inhibiting the soil microorganisms (bacteria, fungi, protozoa and nematodes) that provide natural fertility and plant protection. This can lead to further dependence on chemical inputs to deliver nutrients and protection against pests and diseases – what is called the 'chemical treadmill'.

Regenerative farmers look at the world in a different way. They focus on biology, rather than chemistry. They seek to understand and manipulate ecological processes and natural cycles to grow crops and animals in a profitable way. To use a pithy phrase, they try to 'farm with nature, not against it'.

Regenerative agriculture is based on the following principles:

1. ***Building healthy, biologically-active soils***. This is the foundation for regenerative agriculture, built on a recognition that healthy communities of bacteria, fungi and other soil microorganisms can make nutrients available to plants, protect plants from disease and support functioning carbon, mineral and water cycles through a complex soil food web.
2. ***Maximising photosynthetic activity and living plants across the year***. Living plants, through root exudates, feed the soil microorganisms that are essential to soil health and receive nutrients and other benefits in return. The goal is to maximise the amount of solar energy harvested through growing plants, because much of this will be fed to soil microorganisms through these symbiotic relationships. Keeping soil covered with living plants and plant residues, and avoiding bare soil, also protects soil from erosion and temperature extremes.
3. ***Minimising chemicals and external inputs***. Synthetic fertilisers and agrochemicals (such as pesticides) compromise soil biology and inhibit the symbiotic relationships between soil microbes and plants. They also cost money. Regenerative farmers seek to minimise their reliance on inputs, relying on natural processes (e.g. nitrogen-fixing plants) to support fertility, raising animals on pasture rather than purchased feed and striving for circularity as much as possible.
4. ***Exploiting the benefits of diversity***. Different crops, animals and trees can be grown on the same land in symbiotic ways, with each production system contributing to the other. On-farm diversity recycles nutrients, eliminates waste, and controls pests and diseases (while diversifying revenues).
5. ***Balancing economic, environmental and social goals***. Regenerative farmers pursue a broader set of goals – such as improved soils, cleaner water, carbon storage, landscape biodiversity and higher quality food – rather than short-term yield maximisation. This is driven by different value systems, a more holistic view and, in some cases, alternative philosophical or spiritual beliefs, in particular a strong ethical connection to the land.[3]

Principles of regenerative agriculture



These same principles underpin a number of branches of alternative agriculture that have emerged over the last half century: agro-ecology, eco-agriculture, organic, biodynamic, permaculture, conservation agriculture, biological farming, low input sustainable farming. 'Regenerative agriculture' is a useful term that can encompass many of these branches.

This definition excludes controlled environment agriculture, vertical farming, hydroponics and other systems that do not rely on the soil. Food can be grown in this way. It is even possible that these systems have fewer negative externalities than many forms of conventional agriculture, i.e. they 'do less harm'. But they cannot 'do good' in the sense of delivering *positive* environmental externalities in the form of healthier soils, carbon removal, more biodiversity or other ecosystem functions. Therefore, they are not regenerative.

Regenerative agriculture builds on the latest discoveries in soil science and agronomy. We are only now beginning to understand the complex interactions between plants and soil microbiology that influence soil health.[4] For example, glomalin, a glycoprotein that plays a crucial role in binding soil particles together and creating soil fertility, was only discovered for the first time by an American scientist in 1996.[5] In the last decade, there has been a paradigm shift in our understanding of soil carbon: soil scientists discovered that it is mediated by complex interactions between plant roots and microbial communities, overturning traditional, mechanistic, input-output soil models.[6] Biologicals – soil amendments, seed coatings and novel crop protection products – are one of the hottest areas for venture funding today. This is part of an overall shift from chemistry to biology in farming, what we termed the next 'agricultural revolution' in our 2016 white paper.

> ***"Essentially, all life depends upon the soil… There can be no life without soil and no soil without life; they have evolved together"***
> Charles Kellogg, *Soils and Men* (1938)

Farming practices

Regenerative farmers use these principles to select farming practices and design agricultural systems that suit their context. There are a number of farming practices associated with regenerative agriculture.

In cropping systems, regenerative farmers minimise tillage and soil disturbance, plant cover crops and use more diverse crop rotations. This can include ley farming (alternating grain crops with legume-grass pastures) and inter-cropping (growing multiple crops in the same field). They eschew synthetic fertilisers and instead use biological soil amendments such as compost, compost tea or manure. They use integrated pest management techniques to reduce or eliminate chemical pesticides. On irrigated land, they use additional practices for water management and seeding.

Well-managed livestock can play an important role in regenerative agriculture. Regenerative farmers seek to raise animals on pasture for most or all of their lives, using high-density, short-duration grazing practices (also known as holistic planned grazing or adaptive multi-paddock grazing) to maximise forage growth and animal health. They avoid the use of hormones and antibiotics in animals. A key feature of regenerative agriculture is integrating grazing animals into grain crop rotations and orchards in order to control weeds and recycle nutrients.

Regenerative farmers also integrate trees on their farms, either by planting trees on cropland and growing crops in between (agroforestry) or by planting trees on pasture or grazing animals in existing open woodland (silvopasture).

Intensively-managed orchards can use many of the same cropping practices listed above (e.g. reducing tillage, cover crops, biological fertility), while also making better use of pruning residues or end-of-life trees by chipping the wood and incorporating it into the soil.

Regenerative farmers use a number of practices to shape their landscapes, especially the less productive parts of the farm. They create shelterbelts, hedgerows and pollinator strips on field edges to buffer the impact of extreme weather and provide habitat for beneficial insects. They harness the flow of water across their properties by restoring riparian areas, building swales and dams, and using keyline design. They manage non-productive areas to enhance ecosystem functionality (carbon storage, biodiversity, hydrology, nutrient recycling), for example by establishing woodlands or preserving native grassland or other natural habitats.

SLM mixed farming property in Australia

These practices can be implemented at any scale. They are as relevant for a smallholder farmer on 1 or 2 hectares in a developing country as for a commercial operator farming thousands of hectares in the USA or Australia. However, the suitability of any practice depends on local context. There is no one set of regenerative practices that works everywhere. Dr Charles Merfield of New Zealand observed that the modern regenerative agriculture movement developed in drier regions of North America and Australia dominated by extensive arable and livestock systems. This can lead to a more reductive definition of regenerative agriculture that is not fully relevant to temperate regions of Northern Europe or New Zealand, for example.[7] A fuller definition of regenerative agriculture will include practices that are relevant to all ecosystems (which is what we have attempted in this paper).

Regenerative farming practices

Growing crops

- No or minimum tillage
- Cover crops
- Longer, more diverse crop rotations
- Ley farming
- Inter-cropping or polycultures
- Retaining crop residues on soil
- Applying compost, manure, other biological soil amendments
- Using integrated pest management to minimise pesticides
- Reducing or eliminating synthetic fertilisers
- Better irrigation management (e.g. for rice)

Managing livestock

- Raising livestock on pasture for whole life
- Mob grazing / adaptive multi-paddock grazing / holistic grazing techniques
- Integrating grazing animals into crop rotations and orchard management
- Avoiding hormones & antibiotics

Integrating trees

- Planting trees on cropland (agroforestry)
- Planting trees on pasture (silvo-pasture)
- Mulching pruning residues and old trees in orchards

Designing landscapes

- Shelterbelts
- Hedgerows
- Pollination strips
- Riparian area restoration
- Water conservation through landscaping (e.g. keyline)
- Managing non-productive areas for ecological goals

SLM organic olive orchard in Spain

Agricultural systems

Regenerative farmers bundle these practices in different ways to create agricultural systems that grow particular products. These systems reflect biophysical conditions (soils, terrain and climate) but also market conditions (output prices, access to inputs, and infrastructure) and availability of labour (farmer, family and hired workers). The combinations are infinite.

Based on our research, we have profiled a number of systems below with investment potential. They have been selected because they can function at commercial scale, offer economic returns that are as good or better than conventional production models, and are supported by independent research demonstrating their positive environmental impacts. SLM Partners is investing in a number of these systems already.

Organic grain rotations on fertile soils

Farmland in temperate zones with fertile soils and reliable rainfall is usually dominated by the production of a small number of grain or oilseed crops, such as maize (corn), soybeans or wheat. Conventional production methods typically rely on simple rotations (2 or 3 cash crops without cover crops), heavy use of synthetic fertilisers, and broad applications of herbicides, fungicides and insecticides to control weeds and pests. This leads to biologically-inert soils and loss of soil organic matter over time. In many cases, seeds are genetically-modified to confer resistance to herbicides such as glyphosate, leading to its excessive use.

Organic farming excludes the use of synthetic fertilisers, most agrochemicals and genetically-modified seeds. Organic farmers employ more diverse crop rotations, grow cover crops between cash crops, and apply biological fertility such as compost or animal manure. They seek to build more biologically-active soils to cycle nutrients and control pests and diseases, and they typically rely on mechanical methods (such as cultivation) to control weeds. Most organic farmers use some tillage, although some have embraced no-till farming as well. Organic farmers are also more likely to integrate livestock into their grain rotations to provide extra fertility.

Organic farming is regulated by governments and certified by third parties through annual audits. There are separate supply chains for organic grains. Consumers place a value on organic certified food and farmers can earn significant price premiums (which vary from country to country and crop to crop depending on supply-demand dynamics).

Organic farming is still a niche activity but it is growing strongly. In the USA, 1.2% of cropland is certified organic and the area has grown by 72.5% over the last 7 years.[8] In the EU, the organic share of total agricultural land reached 9.6% in 2021. The proportion in Australia was almost the same, at 9.9%.[9] SLM Partners is investing in this system in the US Midwest through separate managed accounts. We have acquired 3,500 hectares of land in this region since 2019, partnered with 19 local farmers through long-term leases, and are converting this land to organic certification.

SLM organic corn field in US Midwest

No-till cropping with diverse cover crops and mob grazing

'No-till' farming, now applied on 37% of US cropland, has emerged as a better way to grow crops in areas of low rainfall and fragile soils. But it typically requires large amounts of herbicides and other pesticides to control weeds and pests, and often employs simple crop rotations dependent on genetically-modified crops with herbicide resistance.

The next generation of no-till is now being developed. These systems combine no-till cropping, diverse cocktails of cover crops and livestock grazing to produce crops and meat. Cash crops (such as wheat, oilseeds, cotton, pulses, hay or sorghum) are grown in extended rotations without tilling of the soil. Diverse cover crops 'cocktails' are planted to ensure 100% soil cover through the year and to provide fertility for the next harvest, supplemented by compost or other biological amendments. Sheep or cattle are strip-grazed on the cover crops and residues, recycling nutrients and providing another revenue stream. Bale grazing can be used to carry animals through the winter outside. The emphasis is on using plant diversity to feed the soil. This allows for the reduction or elimination of synthetic fertilisers and most pesticides (although herbicides are commonly used to control weeds).

These systems are most closely associated with a group of innovative farmers in the northern Great Plains of the USA, especially in the Dakotas, supported by the Natural Resources Conservation Service of the USDA. Gabe Brown is perhaps its most famous practitioner.[10] There are also many successful examples in Australia. Indeed, the modern regenerative agriculture movement has grown out of these drier regions where prevention of soil erosion and conservation of moisture through no-till are critical.[11] SLM Partners, through its joint venture subsidiary Agri Carbon Investments Pty Ltd, began investing in this system in 2023 in New South Wales, Australia, integrating livestock with grain rotations on large farms to grow wheat, canola, chickpeas and other crops.

Canola growing on SLM property in Australia

Holistic planned grazing for beef cattle and sheep

Conventional management of livestock on extensive grasslands (which cover 3.5 billion hectares or 26% of the planet's ice-free landmass) consists of placing small numbers of animals in large areas for long periods of time. The result can be over-grazing and land degradation, which limits stocking rates and erodes profitability.

There is an alternative form of management known as holistic planned grazing. (Other terms are 'adaptive multi-paddock grazing', 'management-intensive rotational grazing' or simply 'regenerative grazing'). This involves using fencing to divide the land into smaller paddocks, grouping animals in larger numbers, and moving them frequently according to a grazing plan that is adapted in response to changing conditions. The goal is for the land to receive sufficient animal impact and then enough time to recover, mimicking the behaviour of grazing animals in the wild. Holistic planned grazing can regenerate pastures, increase grass production and increase stocking rates in commercial cattle and sheep operations.[12]

Holistic planned grazing is being used on millions of hectares worldwide, especially in regions of dry grassland or savannah. There are well-documented case studies from the North America plains, Mexico, Australia, east Africa, and the Patagonian region of Argentina and Chile.[13] For more than a decade, SLM Partners has implemented this grazing system for beef production on more than 250,000 hectares of land in Australia through its SLM Australia Livestock Fund.

Cattle herd on SLM property in Australia

Lower input, pasture-based dairy on multispecies swards

The commercial dairy industry can be divided between confinement systems that rely heavily on grains for feed and pasture-based systems that make use of grass. The latter have many economic and environmental advantages. Yet, even grass-based systems are often based on ryegrass monocultures and high use of nitrogen fertiliser, which can be expensive and environmentally damaging because of nutrient run-off.

Farmers have developed more sustainable, lower input pasture-based systems that make use of more diverse swards (containing grasses, legumes and herbs). They require less fertiliser because legumes fix nitrogen from the air. Using rotational grazing, cattle are grazed in small paddocks for a short period of time before being moved. The focus is on developing biologically active soils and healthy, diverse plants. There is also a strong focus on animal health. These systems sometimes incorporate smaller cattle breeds (e.g. Jersey-Holstein crossbreeds) that perform well on pasture, rather than animals that have been bred for high yields on grains. They avoid growth hormones and minimise use of antibiotics.

Pasture-based dairy is common in high rainfall regions such as New Zealand, Ireland, and parts of Britain, France, the USA and Chile. Within each of these regions there are examples of farmers who have developed lower input, profitable systems that are less reliant on nitrogen fertilisers.[14]

Healthy cows on diverse swards in New Zealand

Regenerative orchards in Mediterranean zones

The production of tree nuts (such as almonds and pistachios) and olives in Mediterranean zones is increasingly dominated by intensive, irrigated orchards. These systems rely on monocultures and heavy use of external inputs, such as synthetic fertilisers and pesticides, to supply nutrients and controls pests and weeds. While this approach can deliver high yields, it can degrade soils and lead to several negative environmental externalities. At the same time, traditional rainfed systems in Mediterranean zones also suffer from land degradation. Soils are often kept bare through tillage or application of herbicides, which can lead to soil erosion, nutrient run-off and loss of soil organic matter.

In recent years, innovative farmers have developed regenerative orchard systems that build soil health, reduce reliance on external inputs, and have a positive impact on biodiversity, water and carbon cycles. Key practices include planting cover crops between tree rows, minimising tillage, using composts and biological fertilisers, mulching the pruning residues, and planting hedgerows or pollinator habitats for integrated pest management. Whole orchard recycling at the end of orchard life – a practice that involves removing old trees, chipping them and incorporating the biomass into the soil – returns organic matter to soils.[15]

Some growers are transitioning orchards to organic certification in order to tap into premium markets. This has its challenges: supplying enough nutrients to the trees, controlling pests and diseases, and managing ground vegetation. But when agronomically and economically viable, it can be a profitable and productive system. Through its funds and separate accounts, SLM Partners is investing in regenerative and organic orchard systems in the US West, Spain and Portugal for the production of almonds, pistachios, walnuts, olives and citrus.

SLM almond orchard in Portugal

Agroforestry

Agroforestry is the integration of trees with cropping or livestock systems. Trees can be grown for timber, fruit, nuts, forage or a combination of products. A variety of crops or grasses can be inter-planted in the alleys between trees, with enough space to allow conventional machines to operate. In livestock systems, the trees can also act as a source of forage for animals, enhance the productivity of the pastures and provide shade for animals. The most common livestock are cattle and sheep, although pigs and poultry can also thrive in woodlands. Systems can be dynamic, transitioning from crops/livestock to timber production as trees mature, or maintain a constant balance between crop/livestock and tree production.

A key objective in agroforestry is complementarity of resource capture. Tree roots extend deeper than crop or grass roots and are therefore able to access soil nutrients and water unavailable to crops or grasses. These nutrients are then recycled via leaf fall onto the soil surface. Trees also capture sunlight energy that may not be utilised by crops or pasture and can provide useful shade to livestock during summer. This is true 'vertical farming', making full use of the 1 metre below the soil surface and the 2 metres above.

There are examples of successful agroforestry systems all over the world, in both temperate and tropical zones. Silvoarable examples include integration of wheat and walnut trees in France; soybeans, corn and pine in North Carolina, USA; wheat and apple trees in England; and palm oil with cassava, maize, legumes or fruit trees in Brazil. One of the most famous silvopastoral examples is the *Dehesa* system in Spain, which incorporates cropping, cattle, free-range Iberian pigs and oak trees. Modern silvopastoral systems have been successfully developed in the southeast USA (mostly cattle and pine trees) and in Colombia. SLM Partners has incorporated agroforestry into some of its investments in Australia, the USA and Portugal.

Wheat and walnut agroforestry in France

Outcomes

There are many ways that the principles and practices of regenerative agriculture can be combined to create context-specific production systems. The section above provides some examples. But the final way that we can differentiate regenerative agriculture from conventional approaches is by measuring its environmental, social and economic impacts. Ultimately, we know regenerative agriculture by its outcomes.[16]

While conventional agriculture is characterised by a focus on yield, regenerative farmers seek to deliver a broader set of outcomes. The most important are:

- Improving soil health
- Addressing climate change
- Enhancing biodiversity
- Improving water quality
- Growing higher quality, nutritious food
- Delivering better economic returns

All these outcomes can and should be measured. An agriculture system that is not producing positive and measurable impacts on soil health, climate stability, biodiversity, water and food quality is not regenerative. And one that is not economically profitable is not even sustainable.

The following sections will explore the environmental, social and economic case for regenerative agriculture based on the latest research.

The positive impacts of regenerative agriculture

The regenerative agriculture movement was born out of increasing recognition of the negative impacts associated with conventional food production. Regenerative agriculture has the potential to deliver important environmental and social impacts, which are essential to the long-term sustainability of our food systems.

Soil health

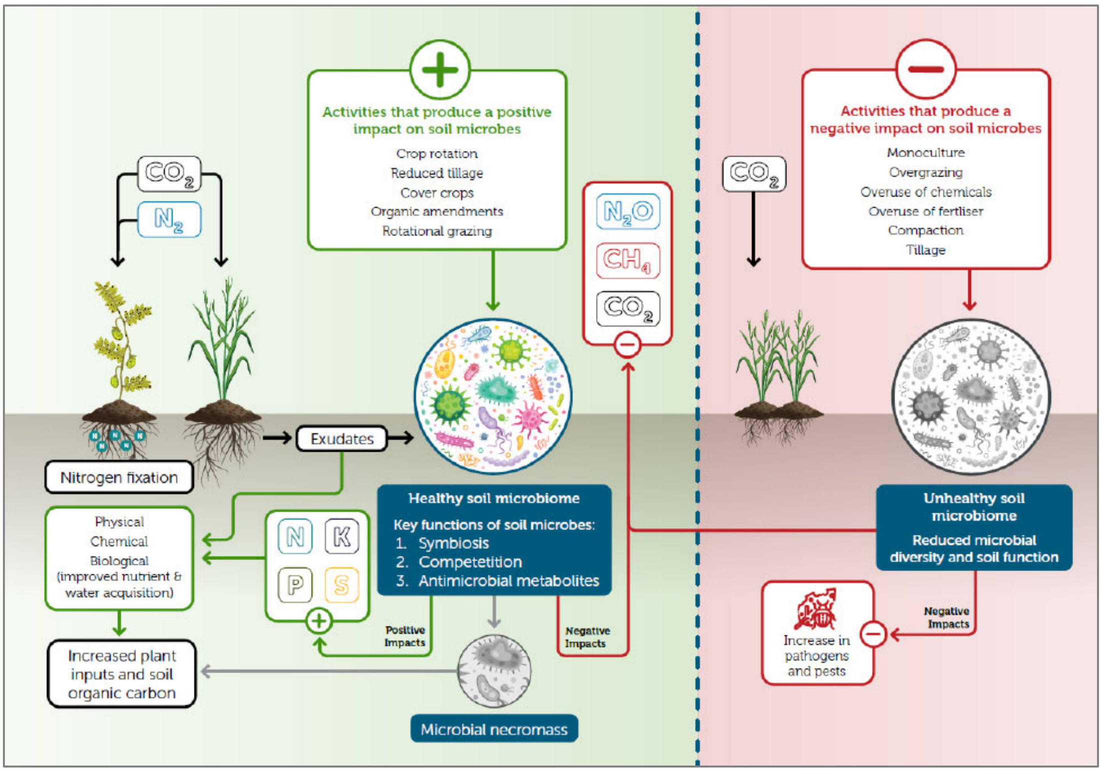
Land degradation is one of the lesser-known risks that humanity faces. Soils underpin the biogeochemical processes required to sustain the production of food, timber and fibre, as well as providing ecosystem services that are necessary for life on earth.[17] Ancient civilisations evolved and subsequently failed by exploiting soils for food and energy until reaching a breaking point.[18]

Destructive farming practices such as over-tilling, use of chemicals, uncontrolled grazing and lack of ground cover can result in soil erosion, compaction, acidification, salinisation and loss of soil microbiology, and therefore a rapid decline in soil health. According to the UN Food and Agriculture Organisation (FAO) most of the world's soil resources are currently in fair, poor or very poor condition, with 33% of land moderately to highly degraded.[19] Half of the world's topsoil has been lost in the past 150 years.[20] A recent study estimates that just under a third of conventionally managed soils have lifespans of <200 years at current rates of soil loss.[21]

The good news is that this process can be mitigated and reversed through regenerative agriculture. Regenerative practices improve the physical structure, chemical properties and microbial life of soils, thereby preventing erosion, making more nutrients available to plants and abating soil-borne diseases. Healthy soils can also mitigate the impact of droughts and floods because of improved water infiltration and water holding capacity.[22] There is a growing body of research on the links between regenerative farming practices and soil health. A major literature review by the Government of Western Australia in 2023 concluded there is strong evidence that regenerative farming practices can restore soil health.[23] A review by the European Academies Science Advisory Council (EASAC) came to the same conclusion, in particular highlighting the role of organic fertilisers in increasing soil organic matter and nutrient availability, especially on degraded soils.[24]

Soil profile from SLM farm in Portugal

Plant, microbe and management interactions that influence soil organic carbon and soil health



Source: R. Khangura et al, 'Regenerative agriculture—a literature review on the practices and mechanisms used to improve soil health', *Sustainability*, 15, 2338 (2023)

A strong proxy for soil health is the percentage of soil organic matter (SOM) in the soil. (This can also be expressed as the amount of soil organic carbon (SOC), which is the biggest part of SOM). Soil organic matter is composed of stable organic material known as humus, plant and animal residues in various stages of decomposition, and the biomass of living organisms. It has extraordinary properties, cycling nutrients, improving soil structure, buffering acidity, retaining water, absorbing pollutants and storing carbon. Soil organic matter also supports a healthy water cycle, retaining water like a sponge and keeping soils moist during dry periods, while creating the porous conditions that allow rapid water infiltration during heavy rain, thereby preventing flooding.[25]

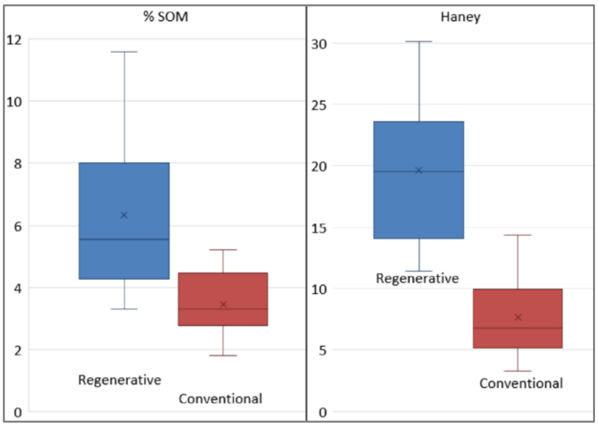
The introduction of agriculture on former grasslands and forests is associated with substantial losses of soil organic matter. Conversely, there are multiple studies showing how regenerative agriculture can increase soil organic matter compared to a historical baseline or to neighbouring farms. For example, research led by Professor David Montgomery of the University of Washington compared 10 regenerative farms with neighbouring conventional farms across the US. They found the regenerative farms had soil organic matter of 3% to 12% (mean = 6.3%), whereas the conventional farms had 2% to 5% (mean = 3.5%). In other words, soil organic matter was on average 80% higher on the regenerative farms. The regenerative farms also scored 3x better on the Haney soil test, which measures soil microbial activity and nutrient availability.[26]

A study of almond orchards in California, carried out by the Ecdysis Foundation and California State University, used a similar comparative approach. They found that regenerative almond orchards averaged 3.88% soil organic matter versus 2.39% for nearby conventional orchards, i.e. 62% higher. The regenerative orchards scored 8.16 on the Haney soil test versus 5.47 for the conventional farms. The soils of the regenerative orchards had more available nitrogen and phosphorus and more active microbial communities. Water infiltration rates were much quicker due to better soil structure and lower soil bulk density: it took 6 times longer for water to infiltrate the conventional soils.[27]

Research on regenerative almond orchards in the southeast of Spain, part of the AlVelAl initiative that seeks to reverse land degradation, produced similar findings. Regenerative farms had on average 31% higher soil organic carbon, as well as better physical, chemical and biological properties. The researchers concluded that 'regenerative agriculture can significantly contribute to the rehabilitation of soil quality in Mediterranean dryland woody agroecosystems'.[28] (One of the regenerative farmers included in this study is now SLM Partners' operational partner in this region.)

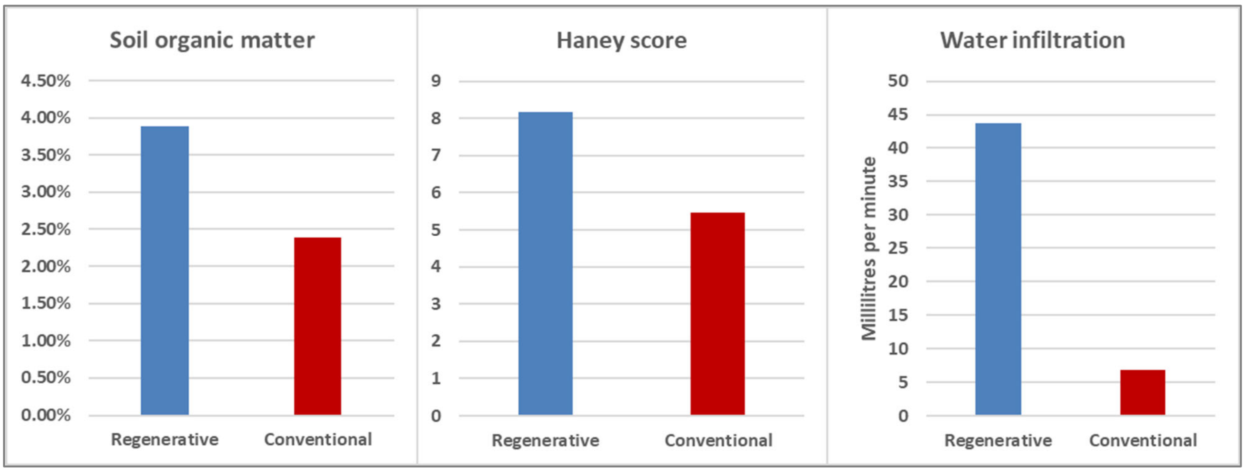
There is a large body of research on the impact of organic agriculture, as organic certification allows for a clear distinction between organic and conventional farms, aiding the design of research projects. Although some poorly-managed organic farms can suffer from soil degradation, the evidence is clear: in general, organic farming is associated with higher levels of soil organic matter and better soil health.[29] For example, one meta study looked at the impact of organic farming practices on 9 soil health indicators across 153 peer-reviewed, published studies. It found a strong association between improvements in soil health and use of

Comparison of regenerative and conventional farms across the US: soil organic matter and Haney soil test



Source: D.R. Montgomery et al, 'Soil health and nutrient density: preliminary comparison of regenerative and conventional farming', PeerJ, 10:e12848 (2022)

Comparison of soil health on regenerative and conventional almond orchards in California



Source: T.L.D. Fenster et al, 'Regenerative almond production systems improve soil health, biodiversity, and profit', *Front. Sustain. Food Syst.*, 5:664359 (2021) crop rotations and minimum tillage. In addition, it found that stacking multiple practices had an additive or synergistic effect compared with practices in isolation.[30] USDA researchers reached similar conclusions based on results from long-term agricultural research sites, even finding that organic systems outperformed conventional no-till systems when it came to levels of soil organic carbon and soil nitrogen fertility.[31] Researchers at the National Soil Project at Northeastern University in the US compared over 1,000 soil samples from organic and conventional farms – the first study on such a large scale – and found that soils on organic farms had 13% higher soil organic matter. More of this was in the form of humic substances that are associated with long-lived carbon, which meant that the organic soils had 26% greater potential for long-term carbon storage.[32]

Measuring soil health can be done through regular soil sampling, using both conventional lab analyses to measure chemical properties and soil organic matter, and newer tests (such as the Haney test) to measure microbial activity. At SLM Partners, we conduct baseline soil sampling on all our properties and then resample every 3-5 years to track change.

Climate change

One of the main reasons why regenerative agriculture is attracting so much attention is the role it can play in addressing climate change. Today, agriculture is responsible for 24% of the world's man-made greenhouse gas (GHG) emissions. About 11% of this is indirect, through deforestation and land use change in tropical regions. The other 13% is direct emissions from agricultural operations. These come from fertiliser use, chemical use, diesel fuel in machinery, and methane emissions from animals and rice production. More broadly, when supply chain activities such as retail, transport, consumption, waste management and packaging are included, the entire food system is responsible for more than one-third of total GHG emissions.[33]

Regenerative agriculture can reduce the direct emissions associated with food production. Often the greatest impact can be achieved by reducing use of synthetic nitrogen fertilisers and instead supplying fertility through cover crops, compost, manure and other biological fertilisers. Most synthetic nitrogen is produced from natural gas (a fossil fuel) through the Haber-Bosch process, which alone accounts for 1.8% of global GHG emissions.[34] In many cases, over half of all applied synthetic nitrogen is lost through conversion to nitrous oxide (N_2O, a greenhouse gas 300 times more potent than carbon dioxide) or leaching from the soil. In the US, for example, N_2O emissions from agriculture represent 4.1% of the country's total GHG emissions.[35] Reducing or eliminating synthetic fertilisers has a major positive impact on the carbon footprint of farming operations. This is why organic farms typically emit from one-half to two-thirds less GHGs per hectare of production than conventional farms.[36]

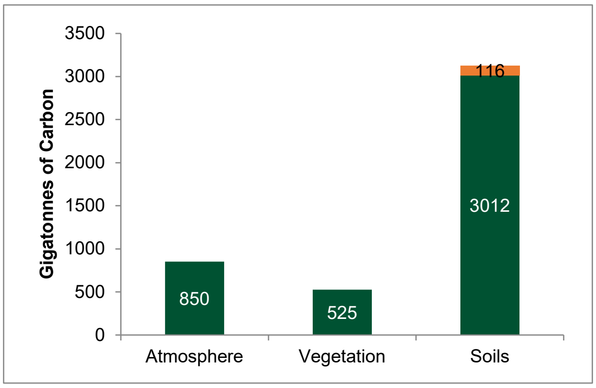
However, the prize is much bigger than reducing emissions. Regenerative agriculture has the potential to turn farms into net carbon sinks. The world's soils store vast amounts of carbon, estimated at 3,012 Gigatonnes (Gt) at 2 metres depth. This equates to more than 5 times the amount of carbon in vegetation and more than 3 times the amount in the atmosphere. Before the development of agriculture, the world's soils held a lot more carbon. It is estimated that soils have lost 116 Gigatonnes of carbon over the last 10,000 years, comparable to roughly one-fifth of cumulative GHG emissions from industry. [37] During this time, cultivated soils on cropland have lost 50% to 70% of their carbon stocks.[38] But some of this soil carbon loss can be reversed through regenerative agriculture. Improving soil health and increasing soil organic matter also increases soil carbon, as more than half of soil organic matter *is* carbon.

How big is this prize? Just how much can regenerative agriculture contribute towards removing carbon from the atmosphere and mitigating climate change? This topic is being intensively researched and there are a range of estimates of the global mitigation potential of agriculture, as summarised in the table below, all using slightly different scopes and methodologies. Broadly, the research indicates that agriculture could contribute more than 5 Gigatonnes of CO2e per year in carbon removals and emissions reductions, which is around 10% of current annual GHG emissions (52 Gigatonnes CO2e per year).

There is a growing recognition – from the Intergovernmental Panel on Climate Change and many research groups – that nature-based solutions, including regenerative agriculture, are essential to putting the world on a Net Zero emissions pathway. Indeed, an analysis by Project Drawdown of the top 100 strategies for removing carbon from the atmosphere placed 8 agriculture-based strategies in the top 20. Project Drawdown point to the loss of carbon from soils over many centuries and conclude that 'bringing that carbon back home through regenerative agriculture is one of the greatest opportunities to address human and climate health, along with the financial well-being of farmers.'[39]

At farm-level, the climate mitigation potential depends on soil type, climate and the type of regenerative practice adopted. The biggest gains in carbon storage per hectare usually come from agroforestry, i.e. planting trees on cropland or pasture. This is followed by the conversion of cropland to permanent grassland or the introduction of perennial pasture into crop rotations. Grazing management can also deliver significant increases in soil carbon.

Terrestrial carbon stocks – and amount lost from soils over last 10,000 years



Source: J. Sanderman et al, 'Soil carbon debt of 12,000 years of human land use', PNAS, 114: 9575–9580 (2017); J. Sanderman et al, 'Correction for Sanderman et al., Soil carbon debt of 12,000 years of human land use', PNAS, 115: E1700 (2018)

Summary of research on climate change mitigation potential of regenerative agriculture

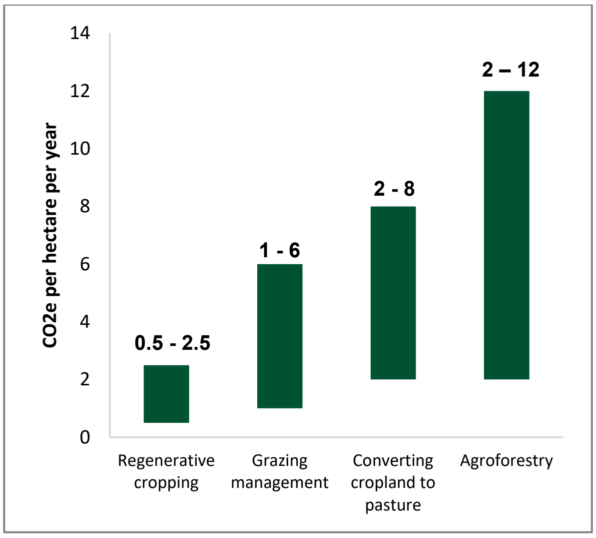
Global mitigation potential (Gt CO2e per year)	Scope	Source
2.6 – 13.6	All agriculture; carbon removals	Project Drawdown (2020)[40]
4.6	All agriculture; carbon removals and emissions reductions	McKinsey & Co. (2020)[41]
2.3 – 9.6	Cropping, livestock, agroforestry	IPCC (2019)[42]
5.3	All agriculture; carbon removals	Fuss et al (2018)[43]
5.3 – 12.2	All agriculture; soil carbon removals	Lal (2018)[44]
3.3 – 6.7	Cropland only; carbon removals	Zomer et al (2017)[45]
5.5 – 6.0	All agriculture; carbon removals & emissions reductions	TNC (2018)[46]
4.8	Selected agri practices; carbon removals & emissions reductions	Griscom et al (2017)[47]
Up to 8	All agriculture; carbon removals & emissions reductions	Paustian et al (2016)[48]

Regenerative cropping practices can increase carbon storage and reduce emissions, although often at a lower rate per hectare because of the amount of disturbance involved. As always, stacking and integrating multiple practices will deliver the greatest impact.

There are case studies of regenerative agriculture systems delivering much higher levels of carbon removal. For example, researchers found that White Oak Pastures, a 1,214-hectare organic livestock farm in Georgia, USA that applies regenerative grazing with multiple animal species, had sequestered 8.4 tonnes of CO2e per hectare per year over a 20-year period.[49] In another study from the southeast USA, the conversion of conventional tilled cropland to pasture, using intensive managed grazing for cattle, achieved extraordinary carbon storage rates of 29.6 tonnes of CO2e per hectare annually over the first 6-7 years (although soil carbon levels then plateaued as soils became saturated).[50] This is why we believe that global studies may under-estimate the potential of regenerative agriculture to contribute to climate change mitigation.

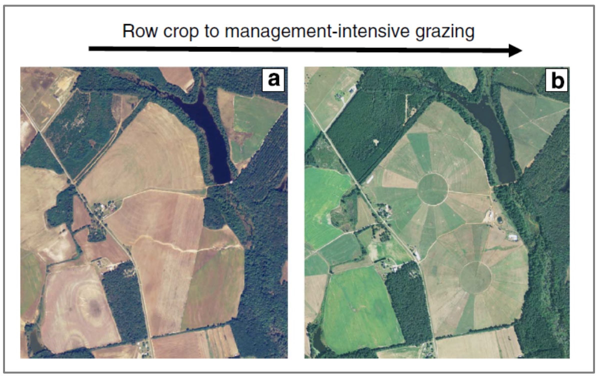
However, GHG accounting on farms is complex. It is possible that a change in practice may increase soil carbon while simultaneously increasing GHG emissions, for example in the form of additional N_2O from manure or methane from livestock.[51] There are well-known issues around permanence as changes in farming practices can lead to the release of stored carbon.[52] The good news is that, driven by carbon markets and government-funded research, there have been major advancements over the last decade in our ability to measure the GHG profile of farming systems. Many new tools are available and costs are coming down. Rigorous measurement involves a combination of soil sampling every 3-5 years and the use of biogeochemical models to estimate changes in on-farm emissions and soil carbon stocks.

Annual per hectare climate change mitigation potential by practice



Source: SLM estimates based on literature review and project experience

Conversion of row cropland to management-intensive grazing in SE USA



Aerial photographs of Wrens Farm taken in 2006 and 2013
Source: M.B. Machmuller, 'Emerging land use practices rapidly increase soil organic matter', *Nature Communication*, 6:6995 (2015)

A word on livestock

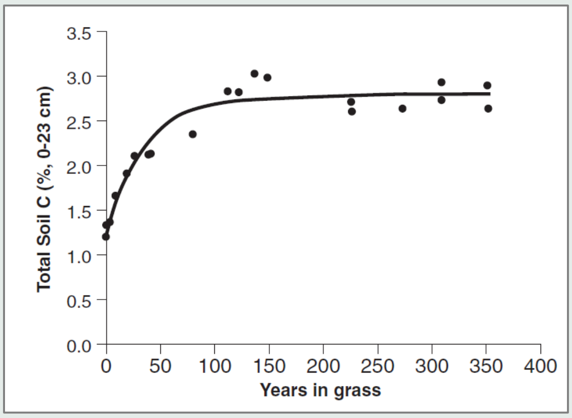
Livestock, especially ruminants such as cattle and sheep, have attracted bad press recently because of their perceived contribution to climate change. As a natural part of their digestion, ruminant animals produce methane, a GHG gas many times more powerful than carbon dioxide. Methane from farmed ruminant animals is responsible for 5.8% of global GHG emissions.[53] Manure from animals is also a source of nitrous oxide. As a result, scientists advocate changes in diet and a reduction in meat consumption in order to tackle climate change. And many investors now have a policy of not investing in livestock agriculture because of sustainability concerns.

Livestock production in conventional agriculture is dominated by concentrated feedlots and housed facilities, where large numbers of animals are confined and fed a grain-based diet sourced externally. As SLM Partners explored in its 2017 white paper *Back to grass: the market potential for U.S. grassfed beef*, there are many environmental problems associated with these systems: poor animal welfare, water and air pollution, and high GHG emissions (without any potential for carbon storage in soils). Many people in rich countries would also have a healthier diet if they reduced their meat consumption.

However, there are alternative production systems based on pasture that can deliver very different outcomes. Well-managed livestock, under regenerative grazing systems, are a powerful tool for increasing soil health and soil carbon, both on permanent grasslands unsuitable for crops and as part of crop rotations.[54] Indeed, we would argue that the most sustainable and regenerative farming systems *require* animals.[55] Deep-rooted grasses push carbon into the soil and improve soil structure. Animals can help control weeds and consume crop residues, and they recycle nutrients and provide natural fertility through their excretions, reducing the need for synthetic fertilisers and herbicides.[56] By allowing animals to express their natural behaviours, these pasture-based systems also deliver better animal welfare outcomes.

When raised as part of regenerative grazing or cropping systems, the GHG profile of livestock can also look very different, as increases in soil carbon can go a long way towards offsetting methane emissions. Converting arable land to grassland is one of the most effective ways to increase soil carbon. The chart below from Rothamstead in the UK, one of the oldest research farms in the world, shows that soil carbon more than doubles after conversion to grassland that is then grazed or mowed.

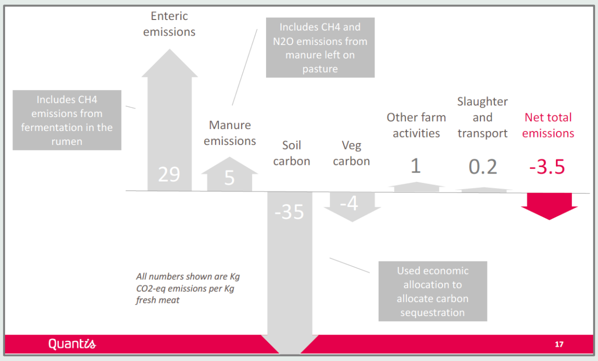
Change in soil carbon after conversion from cultivation to grass



Source: Data from Rothamsted, UK, presented in EASAC, *Regenerative agriculture in Europe*, EASAC policy report 44 (Apr 2022)

Conversion to grassland and holistic planned grazing can radically change the carbon footprint of meat. For example, researchers conducted a full carbon lifecycle analysis for White Oak Pastures, the previously-mentioned organic livestock farm in Georgia, USA that produces beef cattle, sheep, pigs and poultry. They found that carbon sequestration in soils and vegetation was enough to offset 85% of the farm's total GHG emissions. When looking at beef cattle only, the researchers found that the beef produced had negative overall (negative) emissions of -3.5 kg CO_2e per kg of product, i.e. soil carbon storage more than offset enteric methane and other emissions. They concluded that 'at the best case scenario, rotationally grazed beef may be a very unusual case of having a net negative carbon impact from its production'.[57]

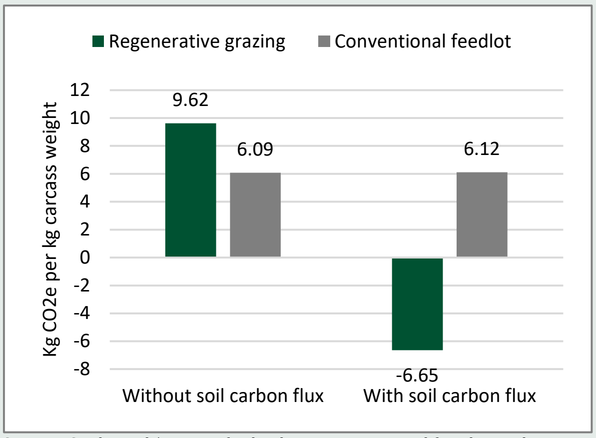
Carbon footprint of beef on White Oak Pastures



Source: Quantis, Carbon footprint evaluation of regenerative grazing at white oak pastures (Feb 2019)

Broader geographic studies have reached similar conclusions. Researchers in the US Midwest compared the GHG profile of a Michigan State University research farm that used regenerative grazing with a conventional feedlot finishing system. They looked at GHG emissions from enteric methane, feed production, manure, and on-farm energy use and transportation, as well as soil carbon sequestration. The data showed that, once soil carbon was taken into account, beef finished in the regenerative grazing system had negative emissions (i.e. a net carbon sink) of −6.65 kg CO_2e per kg carcass weight, whereas feedlot beef had emissions of 6.12 kg CO_2e per kg of product. This research suggests that regenerative grazing can turn the beef finishing phase in the US Midwest into a net carbon sink, thereby contributing to climate change mitigation.[58] Professor Richard Teague of Texas A&M University has conducted similar studies on the Southern US Plains and extrapolated the findings to the North America beef sector, arguing that soil carbon sequestration through better grazing management could offset all beef cattle emissions.[59]

GHG emissions from beef finishing systems in the US Midwest



Source: P. Stanley et al, 'Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems', *Agricultural Systems*, 162 (2018)

There are legitimate questions around whether soil carbon sequestration in grazing systems can offset all methane emissions, and especially whether this effect can continue indefinitely. There is evidence that sequestration rates decline and then plateau as soils reach a saturation point, although it is not clear if this happens over years or decades.[60] One recent study concluded that it was not feasible to rely on carbon sequestration in grasslands to offset the warming effect of all emissions from the current number of ruminants globally.[61]

Yet, there is enough evidence to suggest that certain livestock systems, using regenerative grazing with the right soils and climate, can be carbon neutral. Certainly, ruminants raised in regenerative grazing systems have a substantially different GHG footprint to conventional, confined production systems.[62] Global studies of livestock tend not to account for this, instead applying emissions factors based on conventional methods of production to all animals and therefore unfairly penalising regenerative systems. The type of management matters. As regenerative graziers like to say, 'it's the how, not the cow'.

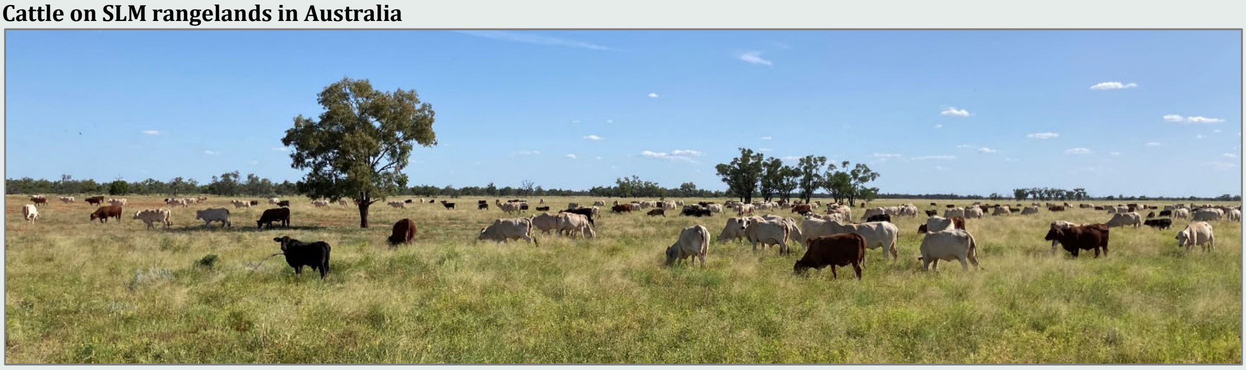
It is also important to view this issue from a systems perspective. What would happen if domesticated animals were removed from the landscape? In some biomes, forestry would naturally return, adding to carbon sinks. But in other biomes, grasslands or savannah would persist and they would be recolonised by wild herbivores that are also a source of methane and nitrous oxide. We need to look at the potential emissions of these wild ruminants (and termites) to understand the true impact of removing domesticated livestock.[63] For example, one study of African savannah found that the GHG emissions from wild herbivores would be similar to domesticated cattle if the land was abandoned by humans.[64] In some brittle environments, removal of grazing animals may also increase the risk of wild fires, as vegetation not consumed by animals is more likely to burn, recycling carbon back into the atmosphere.

We should also understand livestock in the context of broader land use choices and food systems. Ruminant livestock consume grasses with a high cellulose content that humans cannot digest. They can be raised on the large areas of natural and semi-natural grasslands that are unsuitable for arable crops or other intensive forms of agriculture. This is why when French academics modelled a future sustainable European food system based on organic farming practices, healthier diets and the sparing of land for afforestation, they assumed that the amount of red meat produced would stay largely the same, as cattle and sheep would play a valuable role in grazing grasslands and providing fertility for crop rotations, while the numbers of monogastric animals (such as chicken and pigs) would go down, because of lower cereal production and less grain-based animal feed. With these changes, the European food system would have a substantially lower emissions profile than today.[65] A similar study for the UK reached almost identical conclusions, reflecting the integral role of grazing livestock in regenerative farming systems.[66]

Livestock also play a role in maintaining biodiversity. According to the European Academies Science Advisory Council (EASAC), extensive grazing and mowing systems play a central role in maintaining the open landscape structure and biodiversity of European semi-natural grasslands. There are a total of 63 European Natura 2000 habitat types and large areas of High Nature Value (HNV) farmland that depend on extensive livestock systems. Semi-natural grasslands are among Earth's most species-rich ecosystems and an important example of how long-lasting, low-intensity human activities may lead to an outstanding biodiversity.[67]

Livestock raised on pasture in regenerative grazing systems are not an environmental villain. In fact, they can have positive impacts on soil health and ecosystem functionality, while contributing to human food security.

Cattle on SLM rangelands in Australia



Biodiversity

Our planet depends on biodiversity to support critical biological processes, underpin ecological functions, drive environmental resilience and ultimately sustain life. Yet, the world is facing a dangerous and accelerating loss of biodiversity. The global rate of species extinction is at least tens of times, and possibly hundreds of times, higher than the average rate over the past 10 million years.[68] It is estimated that the population sizes of mammals, birds, fish, amphibians and reptiles has declined 68% on average since 1970.[69] There is little doubt that the earth has entered a sixth mass extinction.[70]

The production of food has been the primary cause of biodiversity loss globally in the last 50 years.[71] Indeed, one McKinsey analysis claims that agriculture is responsible for 85% of all biodiversity loss.[72] This is mostly driven by the conversion of natural habitat to agriculture and the intensification of agricultural systems. The heavy reliance on synthetic fertilisers and pesticides undermines biodiversity at the farm level and can lead to nutrient and chemical runoff into waterways and oceans.[73] The reliance on monocultures and lack of landscape diversity removes suitable habitats. Wild mammals, birds, reptiles, insects, pollinators and aquatic life all suffer, as well as the vital macro and microorganisms that live below the ground.

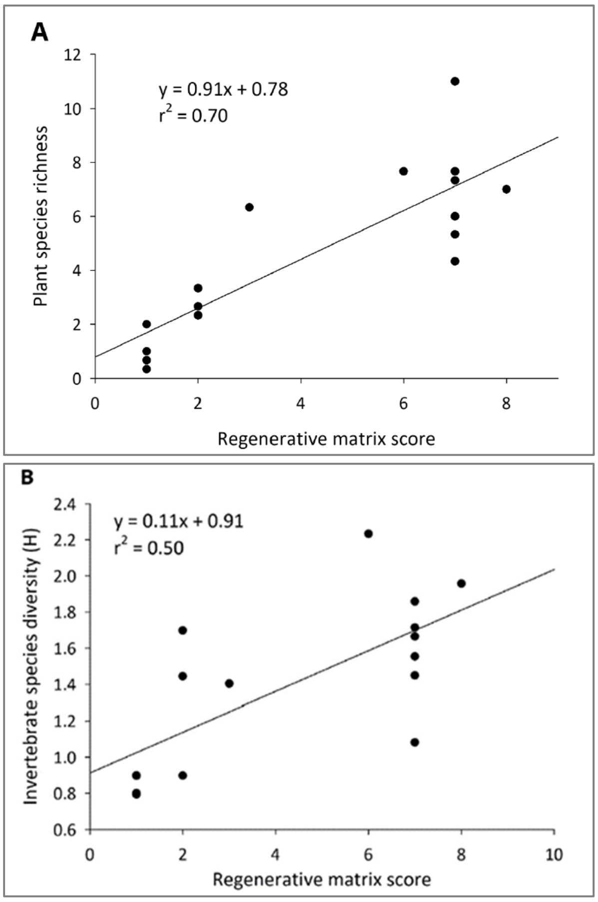
Reversing biodiversity loss means not just protecting natural habitats but promoting biodiversity-friendly practices on agricultural land as well. Agricultural land covers 4.9 billion hectares, or 38% of the world's terrestrial area, so the impact can be huge. Regenerative agriculture can play a role. The same McKinsey report states that changes to agriculture could deliver 72% of the total potential improvement in biodiversity loss identified.[74] By reducing or eliminating pesticides, embracing more diverse crop rotations and land uses, avoiding bare ground and managing non-productive areas, regenerative agriculture can increase biodiversity on-farm and in surrounding areas.

This is backed up by academic research. For example, a study by the Food and Land Use Coalition that synthesized 127 meta-analytic reviews found that crop diversification and low or no tillage practices have a significant positive effect on biodiversity outcomes.[75] In a 2021 paper, researchers from the Ecdysis Foundation and US universities, who studied 52 regenerative farms in the Upper Midwest, Northern Plains and California, found a clear correlation between regenerative practices and levels of plant and invertebrate diversity on the farms, as illustrated by the charts on the next page.[76]

Cover crop in regenerative orchard

Hedgerow on SLM property in US

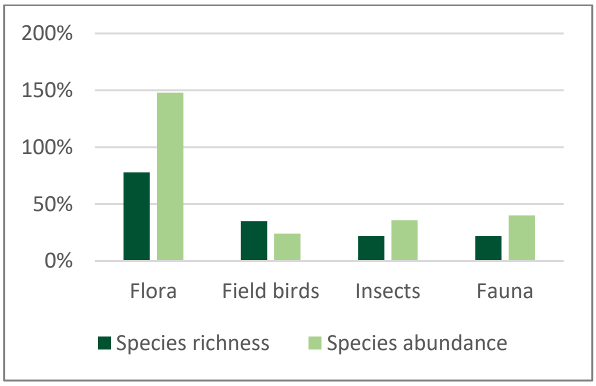
Plant species richness and invertebrate species diversity in California almond orchards.



Source: T.L.D. Fenster et al, 'Defining and validating regenerative farm systems using a composite of ranked agricultural practices', *F1000Research*, 10:115 (2021)

There is a considerable body of research showing how organic agriculture improves biodiversity outcomes. By eschewing most chemical pesticides, organic farms provide healthier habitat for soil microbes, invertebrates, pollinators, and the pyramid of species that rely on them for food. For example, a 2014 Oxford University meta-analysis found that organic farming increased species richness by 30%, species abundance by 50% and pollinators by 50%, producing broad benefits for biodiversity when compared to industrial farming.[77] A recent 2020 study, which reviewed 98 peer-reviewed papers on temperate climate agriculture, found clear evidence that organic farming had a positive impact on species richness and abundance. They found that the richness and abundance of flora, field birds, insects and fauna were significantly higher on organic farms – as shown in the chart below. 'Our study', the researchers concluded, 'underlines that organic farming can play an effective role in acting against the loss of biodiversity'.[78]

Increase in biodiversity on organic vs conventional farms



Source: K. Stein-Bachinger et al, 'To what extent does organic farming promote species richness and abundance in temperate climates? A review', *Org. Agr.*, 11 (2020)

Water

In some climates, irrigation is required to grow food reliably, and irrigation for agriculture now accounts for 70% of freshwater withdrawals worldwide. Water scarcity has become a global problem with 3.2 billion people living in agricultural areas with high or very high water shortage or scarcity.[79] This trend will be further exacerbated by climate change, with rainfall patterns becoming less reliable and extreme events more common.[80] There is an imperative to increase the efficiency of water use in irrigated farming systems.

Regenerative agriculture can help farmers grow 'more crop per drop'. It is estimated that each 1% increase in soil organic matter increases a soil's water holding capacity by 187,000 litres per hectare.[81] The same practices that promote soil health and soil organic matter help to regulate the flow of water on the landscape by improving water infiltration and water retention in the soil profile, capturing more rainfall and making better use of irrigation.[82]

The positive impact of regenerative agriculture on water is supported by recent research from California. Researchers studying regenerative almonds orchards found that they had higher soil moisture percentages, infiltrated water more quickly and reduced water run-off by 65%. This not only made more water available for the almond trees but could also assist in recharging aquifers as part of California's Sustainable Groundwater Management Act.[83] Another research project in California looked at an organic tomato farm (Park Farm Organics) that used diverse crop rotations, cover cropping, compost, conservation tillage and controlled traffic to improve soil health. This allowed the farmer to use 0.5 acre-feet less of irrigation water and increase water use efficiency by 19% with no significant effect on crop yield. The organically-improved soil enhanced deep moisture storage.[84]

As well as contributing to water use efficiency, regenerative agriculture can also improve water quality. Conventional agriculture is responsible for soil erosion and nutrient run-off that has led to the eutrophication of water bodies, loss of freshwater biodiversity and creation of coastal dead zones. The excess loading of fertilisers and chemicals into rivers and groundwater also poses risks to drinking water quality, even with conventional water treatment.[85] The USDA estimates that 50 million people in the US obtain their drinking water from groundwater that is potentially contaminated by pesticides, nitrates and other agricultural chemicals.

By using inputs more efficiently and preventing nutrient run-off, regenerative farming practices can address these problems. USDA researchers in the US Midwest found that planting cover crops and reducing tillage could reduce annual nitrogen loss in field drainage by about 43%.[86] The Rodale Institute and the Stroud Water Research Center are running a 6-year research project on organic no-till farming in the Delaware River Watershed and initial results show reduced nutrient leaking.[87] A study of Ralf Sauter's almond orchard in California found that his use of nutrient management, conservation cover, mulching, and compost application over 20 years reduced nitrogen losses by 98%.[88]

Water pollution is a major issue for intensive dairy producers in countries such as the Netherlands, New Zealand and Ireland, where government regulation is forcing farmers to change practices. Research from New Zealand indicates that switching from ryegrass monocultures or simple ryegrass-clover swards to diverse, multi-species swards reduces nitrogen leaching by 40%.[89] Building anaerobic digestion facilities is another promising avenue – this is well-developed in Europe and scaling up in the US. It not only recycles nutrients, but also produce sustainable biogas.[90] We are aware of some farmers using large-scale vermiculture (earthworm farms) to process livestock manure and turn it into valuable fertiliser.[91] All these practices can deliver substantial improvements in water quality.

Food quality

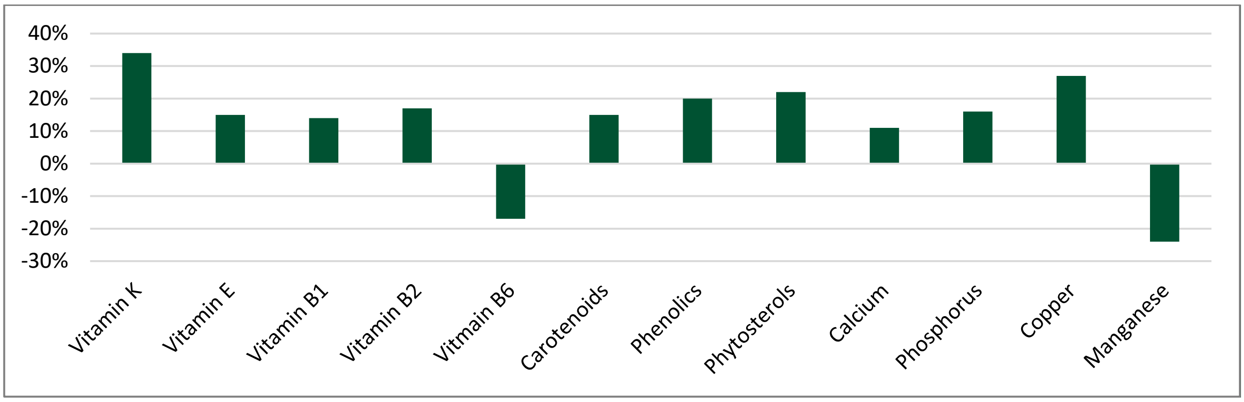
One of the greatest fallacies of the contemporary food system is that it treats all food as equal. The goal is yield per hectare rather than nutritional quality. However, as we explored in our 2016 white paper, there has been an alarming dilution of the nutritional quality of food over the last 100 years. Many vegetables have shown nutrient declines of anywhere from 5% to 40%. Conventionally-grown crops and animal products contain fewer of the minerals, vitamins and phytochemicals that play an important role in human health. Our food is also laced with pesticides, whose effects are not fully understood. The food coming from farms is less tasty, which prompts food companies to load them with sugar, salt, fat or flavours to trick our tastebuds. The world is awash with highly processed and nutritionally poor food – empty calories. This is one reason for the growing epidemic of obesity and diet-related diseases over the last half century, alongside micronutrient malnutrition.[92]

Plant and animal breeding that focused only on yield is partly to blame for this decline in food quality. But another reason is the environment in which our food is grown. Lifeless, degraded soils, and over-use of synthetic fertilisers and pesticides, produce nutritionally-degraded crops. They lack the bacteria and fungi that take up immobile nutrients from the soil and deliver them to plants. Raising animals on these crops in confinement compounds the effect on meat and dairy.

There is increasing evidence to back up the theory that healthy soil = healthy plants = healthy people. In 2022 a seminal paper and book were published by Professor David Montgomery of the University of Washington (who has done more than most to advance the cause of regenerative agriculture). He led research that measured the soil health and nutrient density of crops on 9 pairs of regenerative and conventional farms across the US. The crops included corn, soy, sorghum, and cabbage. The researchers found that the regenerative farms not only had better soil health but also grew crops that had higher levels of certain vitamins, minerals, and phytochemicals relevant to human health. 'These comparisons', they concluded, 'offer preliminary support for the conclusion that regenerative soil-building farming practices can enhance the nutritional profile of conventionally grown plant and animal foods.'[93]

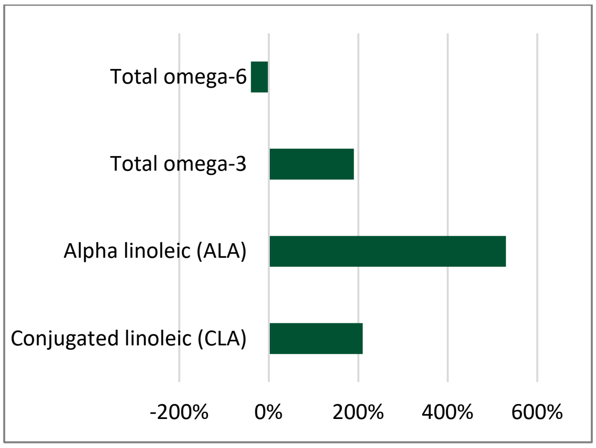
In addition, this same study compared the unsaturated fatty acid profile of beef and pork from animals raised on pasture on a regenerative farm to conventional meat. They found higher levels of omega-3 fats and a more health-beneficial ratio of omega-6 to omega-3 fats, as well as higher levels of conjugated linolenic acid (CLA) and alpha linolenic acid (ALA).[94] This is consistent with earlier research profiled in our 2017 paper on US grassfed beef. There is growing evidence of the health benefits of CLA and omega-3s and, conversely, of the causal links between a high omega-6 to omega-3 ratio and obesity and chronic diseases. There is similar evidence on the health benefits of consuming milk products from grassfed cows compared to those from confinement dairies.[95] The key difference is between animals raised on pasture on a grass diet versus those raised in confinement on grains, although the nutritional profile is best on pasture-based farms using regenerative grazing practices and achieving good soil health.[96]

Crop nutrient density comparison: regenerative vs conventional farms in US



% regenerative farms were higher or lower than conventional
Source: D.R. Montgomery et al, 'Soil health and nutrient density: preliminary comparison of regenerative and conventional farming', *PeerJ*, 10:e12848 (2022)

Beef fatty acids: regenerative vs conventional farms



% regenerative farms were higher or lower than conventional
Source: D.R. Montgomery et al, 'Soil health and nutrient density: preliminary comparison of regenerative and conventional farming', PeerJ, 10:e12848 (2022)

The outcome is less clear when comparing organic certified food and conventional food. A number of such studies have been made and some show nutritional benefits from organic food, especially when looking at beneficial phytochemicals and micronutrients. Other studies do not, especially when they focus on macronutrients. Most studies do show that organic food has lower residues of chemical pesticides and heavy metals, which may have health implications.[97]

The causal pathways between soil health, food nutrient profiles and human health are still being established – this is a novel field of research. (One of intriguing lines of inquiry is around the similarities between our gut microbiome and the soil microbiome, both of which rely on bacteria to break down nutrients.) Yet, there is emerging evidence that regenerative agriculture can produce healthier, more nutritious food, and a fundamentally higher quality product. At least one start-up company is developing a food testing technology that be used to quickly determine the nutritional value of crops and animal products, which opens up the possibility that food buyers and consumers will increasingly differentiate between foods of different quality.

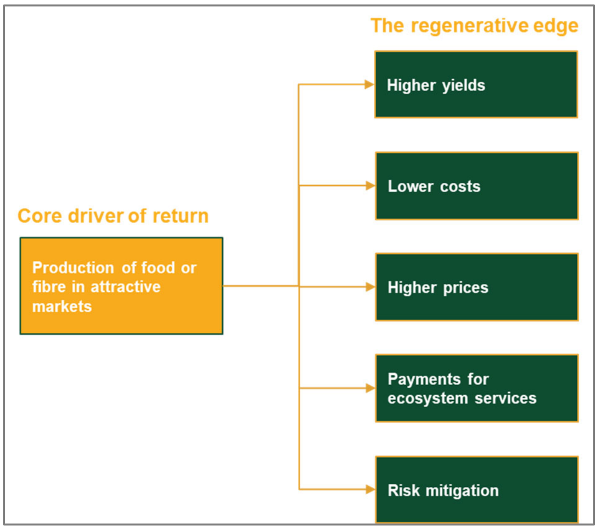
The economics of regenerative agriculture

As the previous chapter has shown, there is compelling evidence for the positive social and environmental impacts that can be achieved through regenerative agriculture. There is an equally strong economic rationale. Regenerative agriculture grew out of dissatisfaction with a conventional model that squeezes farmers between high input costs and volatile commodity prices, neither of which they can control. Average farm incomes in most parts of the world are low. The average age of farmers keeps rising, as younger people stay away from the sector. A goal of regenerative agriculture is to return more economic power to the farmer, not least so that future generations will see farming as an attractive career and life choice.

We believe that regenerative agriculture can be more profitable and deliver superior risk-adjusted financial returns to farmers and to the investors who support them. We call this the "Regenerative Edge". These superior returns will come from one or more of the following levers: higher yields, lower costs, higher output prices, new environmental payments or more stable operating results.

SLM organic soybean field in the US Midwest

Levers of return for regenerative agriculture

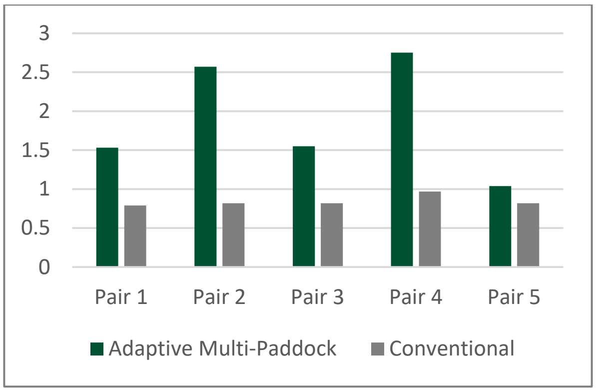


Yields

All else being equal, improvements in soil health should lead to higher yields, especially on degraded land. There is generally a positive relationship between soil organic matter and crop yield. For example, research in Argentina, India, and the West African Sahel has found that per hectare crop yields can be increased by 20–70 kg for wheat, 10–50 kg for rice, and 30–300 kg for maize with every 1,000 kg per hectare increase in soil organic carbon around plant roots. (The effect levels off at higher concentrations, but most of the world's cultivated soils are well below these thresholds.)[98] A global synthesis of 99 meta-analyses assessing 7 crop diversification strategies around the world found that all strategies, except agroforestry, showed a positive median impact on crop yield. They also found that the combination of several crop diversification strategies outperformed any individual strategy.[99] There are also many examples of individual regenerative farmers achieving substantial yield increases at the farm level.

In livestock systems, shifting from conventional set stocking to regenerative grazing (e.g. adaptive multi-paddock grazing) can increase production. An 'across the fence' study of 5 paired conventional and regenerative ranches in the US Southeast found that the regenerative ranches carried 121% (2.2x) more animals. Adaptive multi-paddock grazing resulted in greater forage production as well as a better spread of quality nutritive forage through the year.[100] Our 2016 white paper profiled examples of regenerative grazing achieving carrying capacity increases in drier rangeland ecosystems as well. A recent literature review of dozens of published studies concluded that adaptive multi-paddock grazing delivered, on average, a productivity increase of 20% (along with 18% more soil organic carbon and substantial reductions in nitrous oxide and methane emissions from grasslands).[101]

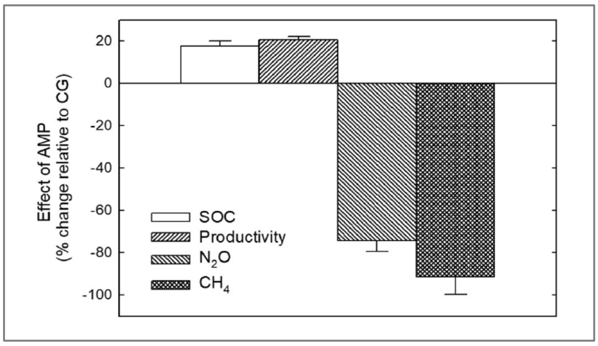
Average animal units carried across different grazing systems in US Southeast



Source: S.I. Apfelbaum et al, 'Vegetation, water infiltration, and soil carbon response to Adaptive Multi-Paddock and Conventional grazing in Southeastern USA ranches', *Journal of Environmental Management*, 308 (2022)

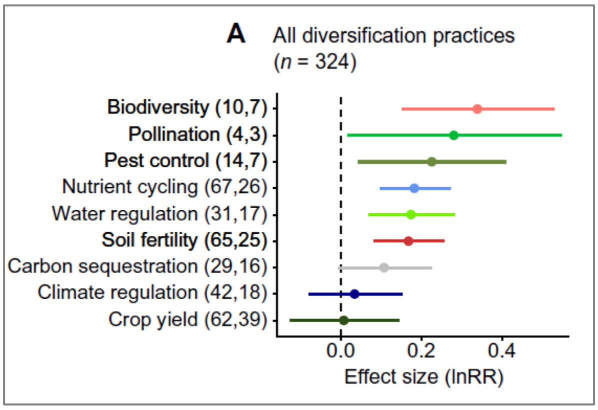
Nonetheless, it is wrong to say that regenerative agriculture *always* increases yield. It is context-dependent. Another meta-analysis that encompassed more than 6,000 original studies on the impact of regenerative farming practices found that some increased yield, some didn't and on average there was no clear effect – although these studies did show substantial positive impacts on environmental indicators such as biodiversity, pollination, carbon sequestration, soil fertility and water regulation.[102]

Impact of adaptive multi-paddock grazing on productivity, carbon and emissions



Source: N. Gomez-Casanovas et al, 'A review of transformative strategies for climate mitigation by grasslands', *Science of the Total Environment*, 799 (2021)

Effect of regenerative practices on crop yield and other indicators (n = 324)



Source: G. Tamburini et al, 'Agricultural diversification promotes multiple ecosystem services without compromising yield', Matt. Sci Adv, 6 (45)

Organic farming systems generally have lower yields. They are constrained by the challenge of supplying the same level of nutrients to crops (especially nitrogen) without synthetic fertilisers, and sometimes by the difficulty of controlling weeds, pests and diseases without chemicals. There are some crops where the yield gap is small or non-existent (e.g. olives, alfalfa). And there are famous examples of organic grain yields getting close to conventional in research trial conditions (e.g. Iowa State University's Long-Term Agroecological Research Experiment or the Rodale Institute's trials), where fields are small and intensively managed. But in commercial, real farm conditions, organic yields are typically lower. This is borne out by academic research: e.g., three scientifically rigorous meta-analyses of organic-conventional crop yield comparisons found that, across all crops, mean yield gaps of organic agriculture are in the region of 19-25%.[103] This is consistent with our experience investing in organic grains and permanent crops in the US Midwest and West Coast.

There is no single story on yield because regenerative farmers do not focus on this as their primary goal. They aim for yield optimization, not yield maximisation. Indeed, regenerative agriculture is a reaction against the dominant productivist framework that encouraged farmers to strive for the highest yield per hectare, regardless of the cost. Regenerative farmers instead focus on profitability. And higher profitability can be achieved in other ways.

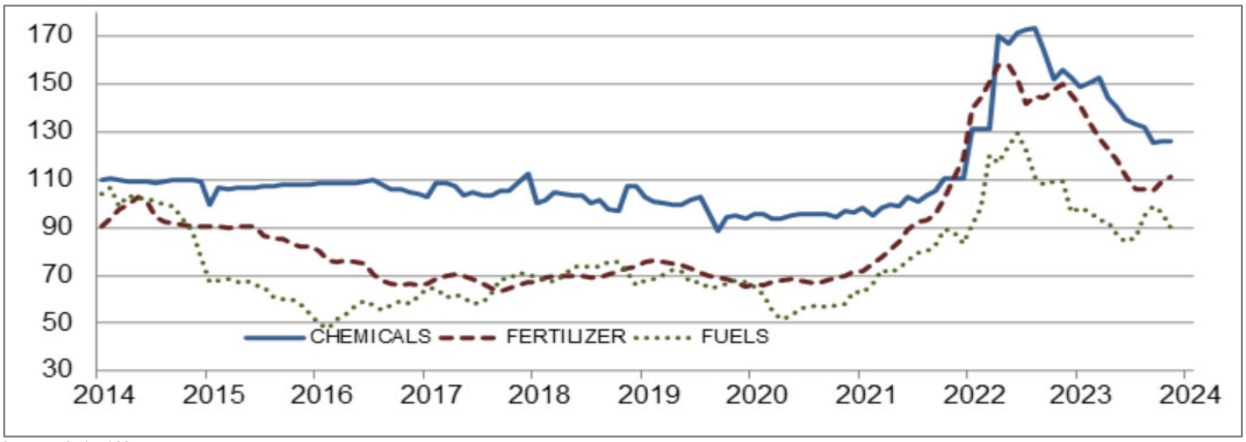
Costs

A key advantage of regenerative farming systems is that they seek to minimise the use of external inputs such as fuel, fertilisers, pesticides and expensive seeds. Instead of buying in fertilisers, farmers look to replenish fertility by planting cover crops, rotating nitrogen-fixing crops, applying organic composts and integrating livestock with cropping systems. Above all, they try to maximise the biological health of the soil, as it is the action of bacteria, fungi, worms and other insects that converts insoluble minerals into plant-available forms, thereby making the most of the soil's natural fertility. This can lead to impressive reductions in, or elimination of, synthetic fertilisers. They also rely on integrated pest management – combining crop rotations and ecosystem diversity – to control pests, weeds and diseases.

Reducing input costs has become a pressing issue for conventional farmers over the last 2 years. There was a massive spike in fertiliser prices following the Russian invasion of Ukraine in February 2022. The price more than doubled in a number of months. The price of diesel and agrochemicals also spiked at the same time. Input costs have risen steadily over the past 30 years, often at a faster pace than food prices, eroding farmer margins, and leaving them vulnerable to sudden cost spikes. This is one of the main motivations for farmers to embrace regenerative practices.

There are many examples of regenerative systems leading to significant decreases in input costs. For example, research from Ireland,

Indexes of chemical, fertiliser and fuel costs for farmers, USA: 2011=100



Source: USDA NASS

France and Switzerland on pasture-based dairy shows that incorporating a high proportion of legumes into diverse swards could reduce nitrogen fertiliser use by a half to one-third, while delivering the same milk yields, significantly reducing production costs.[104] Also in Europe, the Catch C182 project studied the costs involved in applying best management practices (crop rotation, reduced tillage, nutrient management, crop residue management, water management and grassland management) to 24 farms across 9 EU Member States and found that costs were reduced without any effect on crop yields.[105]

Many regenerative farmers seek to eliminate synthetic fertilisers entirely, and to remove all insecticides and fungicides from their system. For example, Ian and Di Haggerty in Western Australia have developed a 'natural farming intelligence' system that relies on direct drilling of crops, the use of compost teas and biologicals to stimulate soil life (via seed coat liquid injections or foliar sprays), and integrated sheep grazing to produce wheat, lambs and wool on 24,000 hectares in a low rainfall environment. They have not used chemical nitrogen, phosphorus, potassium fertilisers or pesticides for the last 18 years.[106] On the other side of Australia, Colin Seis grows crops and sheep on 840 hectares in a higher rainfall environment in New South Wales, using holistic planned grazing and 'pasture cropping' to plant annual crops directly into perennial pasture. He was able to take out many of his inputs, reducing annual costs by over AU$120,000 (while increasing soil carbon by 203%). His farm consistently outperforms other farms when benchmarked against the relevant economic data.[107]

Globally, McKinsey & Co. state in their major report on natural capital that 'regenerative agriculture, if fully implemented, could reduce farm operational and input costs and would therefore be ROI positive, potentially providing $65 billion in value annually.'[108]

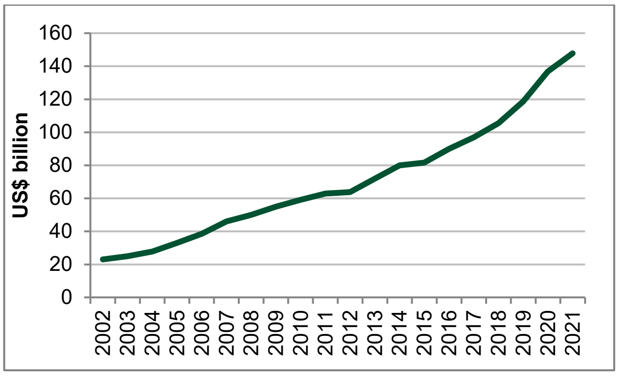
A note of caution. Regenerative agriculture will not lead to a reduced cost structure if it simply swaps purchased inputs for more labour. This can be a risk with more complex ecological farming systems (e.g. polycropping or permaculture) that rely heavily on manual labour or require more mechanical operations at a small scale. The other great challenge, for *all* agriculture, is finding people willing to work on the land. The cost of labour is escalating at an even faster pace than the costs of inputs. Therefore, we must find ways to design regenerative agricultural systems that make the most of mechanisation and scale. In the future, robotics will almost certainly play a role. For example, robotic weeding machines could replace herbicides and make organic farming less costly. This is what 21st century regenerative agriculture will look like.

Price premiums

Even if yields and costs are the same, regenerative agriculture can be more profitable if it can command higher prices for its products. One of the motivations for the regenerative agriculture movement is dissatisfaction with a commoditised food system in which increasingly big corporations squeeze farmers on price: for example, US farmers receive on average just 14.6 cents for every dollar consumers spend on food today.[109] As a result, many regenerative farmers try to de-commoditise their products and achieve price premiums through alternative marketing strategies. Their goal is to grow higher quality food that can command a higher price in the market.

The most developed premium market is for organic products. Organic certification is clearly defined, it has been regulated by governments

Global sales of organic products, 2002-21



Source: FiBL & IFOAM

by more than 20 years, and it has strong consumer awareness and support. The organic market continues to grow strongly: the value of the global market grew from $23bn in 2002 to $148bn in 2021, an annualised growth rate of 9.7%. The two largest markets are North America and Europe, which account for more than 90% of total sales. Consumers, especially younger generations, perceive organic food as healthier and more sustainable and they are willing to pay a premium for it.[110]

This translates into price premiums for farmers at the farmgate, although this varies across crops and geographies. In the US, organic maize (corn) and soybeans have averaged more than twice the price of conventional maize and soybeans over the last 20 years periods. In the EU and UK, organic wheat commanded a similar price premium a decade ago, but this has eroded as supplies have increased, and the premium is now around 40-45%. Organic price premiums for specialty crops, especially fresh fruit and vegetables, can vary considerably over time, usually in response to fluctuations in supply. Organic price premiums for a range of crops in 2023 are shown in the table below. These premiums are often more than enough to make up for any yield declines due to organic farming.

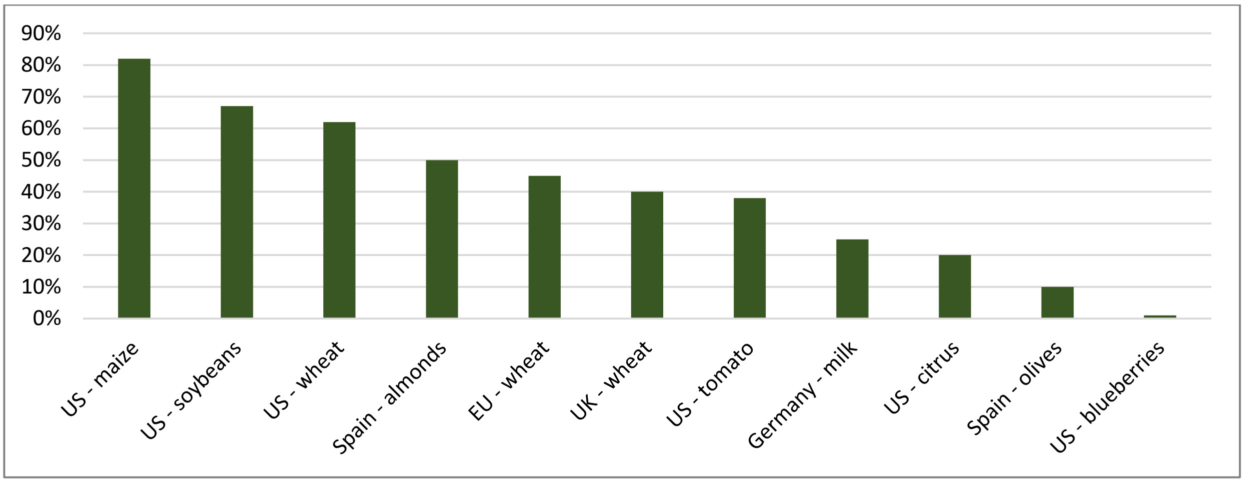
Outside of the organic marketplace, there are other attributes that can achieve price premiums. One of them, at least in the US, is grass-fed, pasture-raised meat. In 2017 we conducted a study on the US grassfed beef market in conjunction with Bonterra Partners and the Stone Barns Center for Food & Agriculture. We found that grassfed beef commanded a premium of 70% on supermarket shelves. Consumers were willing to pay more for meat raised in a more natural way, without antibiotics, growth hormones or grain feeding. Because of inefficiencies in the supply chain, grassfed livestock producers only achieved premiums of 25-30% at the farmgate.[111]

A number of groups are also working on broader certification schemes for regenerative agriculture (outside of organics). They include RegenAgri, Regenified, Certified Regenerative by AGW and the Savory Institute's Ecological Outcome Verification. There is also the Regenerative Organic Certification (ROC), which acts as a higher standard for organic producers.

There is little evidence of these regenerative certifications delivering strong, reliable price premiums to farmers yet. Although many well-known food companies have made big announcements about regenerative agriculture over the last 3 years,[112] their sourcing teams are typically unwilling to pay a premium over commodity prices. For example, of the 50 agrifood companies identified by investor network FAIRR as having regenerative agriculture initiatives, only 4 were actually paying farmers to change practices.[113] This can cause frustration among farmers, as they are being asked by buyers to change practices and engage in time-consuming verification processes without any extra value being ascribed to their product.

There is some evidence of premiums for non-food products. We are aware of RegenAgri-

Organic premiums at farmgate, selected products, 2023



Source: SLM Partners, from multiple sources

certified growers receiving premiums for regenerative cotton. Similarly, a Responsible Wool Standard is starting to offer premiums to sheep producers who implement certain practices and get certified. Surprisingly, it seems that clothing companies are more willing to pay premiums for regenerative certified commodities than food companies.

Overall, we are sceptical that regenerative (non-organic) certification will deliver broad-based price premiums for farmers in the near-term. Consumers are assailed by so many claims about their food ('natural', 'non-GMO', 'deforestation-free', 'Fair Trade', 'carbon neutral', etc.) that it is hard to see a regenerative label breaking through. It has taken 20+ years of marketing and consumer education, backed by government regulation and funding, for the organic label to achieve its current status. Therefore, we tend not to assume any specific premiums for regenerative agriculture, outside of organic certification, in our investments.

There are some exceptions to this rule. It may be possible for farmers to align themselves with food companies – usually younger, smaller companies – that are building genuine brands around regenerative agriculture, charging a premium to their customers and passing some of this premium back to their suppliers. One example is Wildfarmed in the UK. This start-up promotes a rigorous regenerative farming system involving inter-cropping, cover crops, livestock integration, no pesticides and limited synthetic nitrogen to grow wheat. The company has created a strong brand and sells flour at a premium to bakers and supermarkets. It has signed up 95 farmers and is able to pay them a significant premium for their wheat (often >75% above conventional).[114] This is one of the few examples we know of a non-organic, regenerative price premium being paid at scale for a staple food crop.

One final way that regenerative agriculture can deliver price premiums is by allowing farmers to sell directly to consumers, effectively creating their own brand. Our 2017 study into US grassfed beef found that regenerative producers could achieve higher prices by selling meat directly to consumers via farmers' markets or similar channels. Recently, internet-based companies have emerged to connect consumers directly to farmers through a sort of virtual farmers' market. One example from Europe is CrowdFarming, which sources organic fruits, nuts and olive oil from farmers in southern Europe and sells directly to consumers in northern Europe, allowing farmers to earn a retail price, rather than a wholesale price, for their products. They work with more than 400 farmers and sell more than €50 million of products each year.

These direct-to-consumer channels may incorporate third-party certifications as well but they rely more on the trust and transparency that farmers and selling platforms can establish with consumers. It is not clear how scalable they are. They often work best for smaller farmers with strong storytelling abilities, and they serve an educated and motivated niche consumer.

As we have seen, there is evidence that food grown with regenerative practices is more nutritious and healthier, while being good for the environment. This opens up the possibility that farmers can sell their product for a higher price, outside commodity markets. The most developed opportunity is the organic market – it is possible to build investment strategies around this, study historic price data and assume organic price premiums in the future. Outside of this, the situation is less clear. Farmers will need an active marketing strategy and the right partnerships to capture premiums. Opportunities exist, but caution is required when assuming broad-based premiums for regeneratively-grown, non-organic products.

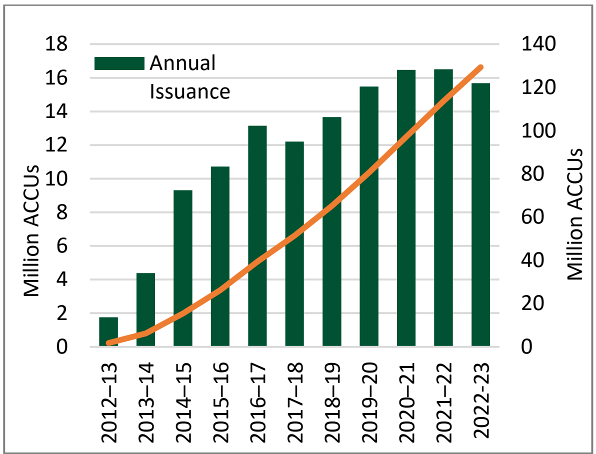
Environmental payments

The negative impacts, or externalities, associated with conventional farming are well-documented. Regenerative agriculture can reverse these impacts and create positive externalities. There are encouraging signs that farmers could be paid by society for these positive externalities. This could create new revenue streams for farmers and landowners.

In the near-term, the most likely way this will happen is by paying farmers for carbon. This can include removing CO2 from the atmosphere through increased soil carbon or above-ground vegetation (e.g. tree planting) and/or reducing agricultural GHG emissions. Across the world, governments, non-profits and start-up companies are developing schemes to measure, verify and register carbon credits (or carbon offsets) from land. There are both regulated compliance schemes, whereby companies are required to purchase carbon credits to stay within caps on GHG emissions, and voluntary carbon markets, through which companies buy carbon credits to meet voluntary commitments on reducing GHG emissions.

Australia is many years ahead of Europe and the US, and it provides an indication of how these markets could develop. Australia has a regulated compliance carbon market with a number of approved methodologies that allow landowners to generate and sell Australian Carbon Credit Units (ACCUS) to high-emitting industries. One ACCU is equivalent to 1 tonne of CO2 emissions avoided or removed. Since 2011, more than 135 million ACCUs have been issued by the Clean Energy Regulator. The volume and value of these credits has increased significantly in recent years, with ACCUs now trading at around AU$35 per tonne of CO2e (equivalent to US$23).[115]

ACCU issuances



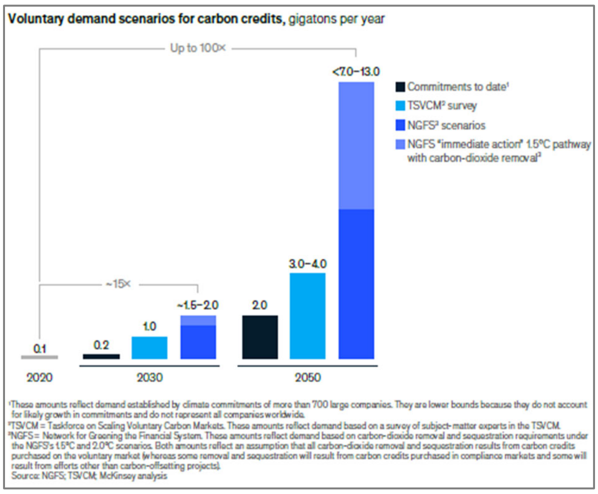
Source: CER, *Quarterly Carbon Market Report – September Quarter 2023* (2023)

We were an early participant in these schemes, creating 4 projects in 2015 and 2016 that are set to generate 4.5 million tonnes of CO2 removal over 25 years from regeneration of native woodland on our farms. By the end of 2022, we had sold more than AU$20 million of ACCUs through contracts with the Australian government. We are now developing new projects on farm properties through our Australian subsidiary Agri Carbon Investments Pty Ltd, this time focused on soil carbon, planting of native vegetation and afforestation. Australia is one geography where we are comfortable with assuming carbon revenues in our investment modelling. With the right strategy, we believe it can add 1-2% to a net Internal Rate of Return (IRR).

Agriculture is mostly excluded from compliance carbon markets in other countries. But there are voluntary carbon markets through which corporates purchase carbon credits in order to offset their emissions and make claims on their overall climate footprint. The total value of traded voluntary carbon credits surged to $2 billion in 2022 and remained at the same level in 2023.[116] There are varying estimates of how big this market could become, as shown in the chart below, but the Taskforce on Scaling Voluntary Carbon Markets estimates there could be demand for 3-4 billion carbon credits annually by 2050, with a market value of >$100 billion.[117]

Already there is strong demand for credits from regenerative agriculture in both the US and Europe. A number of voluntary schemes have been established in the last 5 years, and credits are being sold at >$30 per tonne, although at small volumes. There are substantial premiums for carbon removal credits (compared to avoided deforestation, for example) and for high quality carbon projects in the US and Europe (instead of tropical regions). SLM Partners has established partnerships with carbon

Projections for voluntary carbon credits demand



Source: McKinsey_a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

developers in the US and EU, for both annual and permanent crops, and we are rolling out carbon programmes across all our farms that qualify. At current carbon prices, these schemes could deliver additional revenues of $30-90 per hectare. This is not economically significant on high value farmland, such as irrigated orchards or high-grade arable land, which often trades at >$40,000 per hectare. But it could be significant on lower value cropland or grazing land. If carbon prices reach $100, which many economists think is necessary to incentivise real change in emissions, the equation will, of course, change.

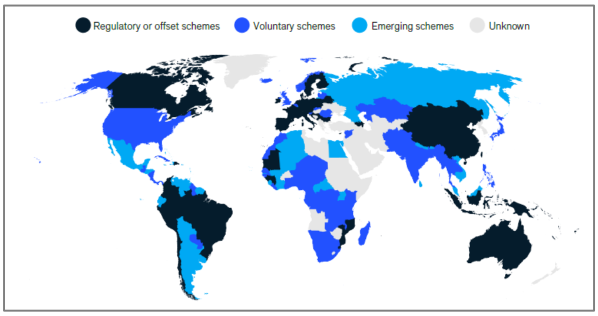
In certain regions, regenerative farmers can also be paid for the positive impacts they make to water quality. In the US Midwest, the Soil & Water Outcomes Fund had enrolled 240,000 acres (97,000 ha) by the end of 2022 and paid farmers an average of $31 per acre ($76 per ha), partly for the reduction in nutrient run-off achieved.[118] In Australia, the Queensland government has established a Reef Credit Scheme to pay farmers to reduce the sediment and nutrient run-off that is currently damaging the Great Barrier Reef. There are a number of schemes in the EU where water companies or local authorities pay farmers to plant trees or take other steps to reduce nutrient run-off.[119]

The newest type of environmental payment that could benefit farmers is for biodiversity. The USA has a well-established system by which developers who destroy sensitive wetlands or endangered species habitats must offset this by paying for the restoration or conservation of similar areas elsewhere. The UK has introduced a Biodiversity Net Gain law that will force developers to fund offsets there, while Australia is introducing a similar scheme. In Europe, carbon credits from projects that also deliver positive biodiversity impacts attract a premium in the market – they are marketed as 'Carbon Plus'.

Biodiversity is harder to measure and less fungible than carbon removals and emissions reduction. The drivers of demand for biodiversity credits are less clear. As a result, biodiversity payments are nascent. Some people believe that biodiversity payments could someday be worth more to farmers than carbon credits.[120] The Taskforce on Nature-related Financial Disclosures (TNFD), by creating a reporting framework and an expectation that companies should measure their impact on nature, may start the ball rolling.[121] Nonetheless, payments for biodiversity are more for the future than the present.

Payments for carbon removal, water quality or biodiversity enhancement can create an entirely new revenue stream for farmers and landowners. In Australia (and New Zealand), these are already sufficiently established to affect investment and land use decisions. Other countries are catching up.

Environmental credit schemes are gaining momentum around the world



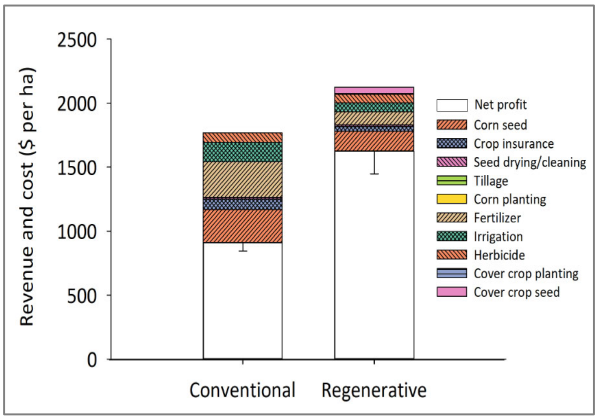
Source: McKinsey & Co., Nature in the balance: What companies can do to restore natural capital (Dec 2022)

Overall profitability

Any one of higher yields, lower costs, higher prices or new environmental payments can be enough to deliver superior profitability. A number of recent studies have assessed the overall profitability of regenerative farming, with positive results.

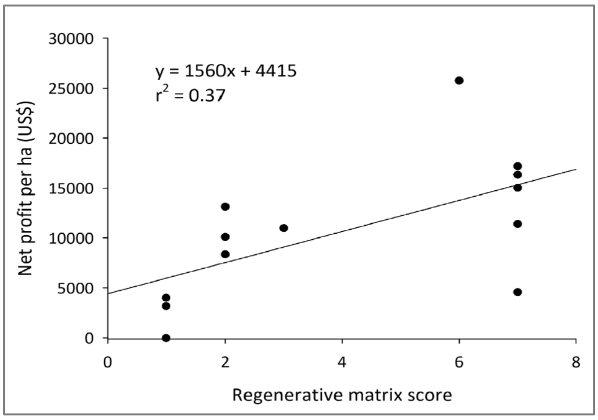
The most compelling evidence comes from farm-level studies that use data from real operations. Researchers from South Dakota State University and the Ecdysis Foundation looked at corn production on 10 regenerative and conventional farms in the US Northern Plains. The most regenerative systems used mixed multi-species cover crops, never tilled, used no insecticides, and grazed livestock on their cropland. They found that regenerative corn fields had 70% higher profits over traditional corn production systems. Yields were lower but this was more than compensated by lower seed and fertiliser costs and higher revenue (from organic premiums and/or livestock grazing on the same fields). Interestingly, the amount of profit was correlated with the level of particulate soil organic matter and good soil structure, showing a strong link to soil health.[122]

Profitability of regenerative vs conventional corn fields in US Northern Plains



Source: C. LaCanne & J. Lundgren, 'Regenerative agriculture: merging farming and natural resource conservation Profitably', *PeerJ*, 6:e4428 (2018)

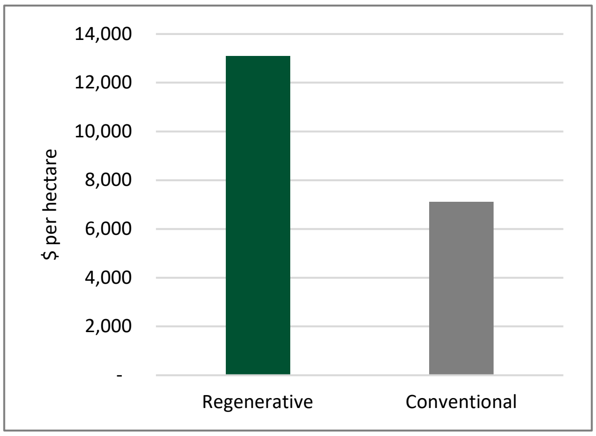
Correlation between regen practices & profit almond orchards in California



Source: T.L.D. Fenster et al, 'Defining and validating regenerative farm systems using a composite of ranked agricultural practices', *F1000Research*, 10:115 (2021)

A similar study looked at the profitability of regenerative almond orchards in California. It found that regenerative systems were more than twice as profitable per hectare than nearby conventional orchards. This was largely due to organic premiums driving higher revenue, although the researchers concluded that profitability would be equal or greater even without these premiums. There was also a clear relationship between the number of regenerative practices adopted and the profitability of the orchards.[123]

Profitability of regenerative and conventional almond orchards in California

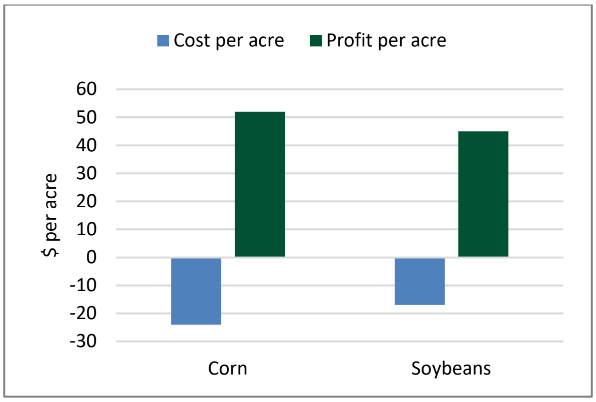


Source: T.L.D. Fenster et al, 'Defining and validating regenerative farm systems using a composite of ranked agricultural practices', *F1000Research*, 10:115 (2021)

In 2021, the Soil Health Institute in the US interviewed 100 farmers across 9 states to measure the impacts of soil health practices on farm budgets. Across the 100 participating farms, they found that net income increased for 85% of farmers growing corn and 88% of farmers growing soybeans, and that 67% of farmers reported increased yields. On average, adopting soil health practices reduced average corn production costs by $24 per acre and soybean production costs by $17 per acre, while increasing net farm income by $52 per acre for corn and $45 per acre for soybeans.[124] Similar case study analysis by the American Farmland Trust and the Environmental Defense Fund also points to higher profitability from adopting regenerative practices.[125]

There is plenty of evidence that organic farming systems tend to be more profitable. At a global level, a meta-analysis of 40 years of studies of 55 crops grown on five continents found that organic agriculture increased farmers' profitability by 22-35% over non-organic production.126 We researched the economics of organic grain production in the US Midwest in our 2019 white paper Investing in U.S. organic grains production. Updated to today, the contrast between organic and conventional

Impact of adopting soil health practices: 100 farmers in 9 US states



Source: Soil Health Institute & Cargill, Economics of soil health systems on 100 farms (2021)

systems is stark. The University of Illinois estimates that average conventional farmers in Northern Illinois will lose $140 per acre on corn and $30 per acre on soybeans in 2024 at current low commodity prices, after taking into account land costs (i.e. rent). In contrast, good organic farmers in our network are projected to earn $592 from corn and $495 from soybeans. See table below. The positive case for regenerative profitability has also been made by a number of high-level studies by consulting firms and foundations. These papers present case studies, but they are often theoretical and model-based, rather than drawing on real farm data, and they are not academically rigorous. Their assumptions and methodologies are not explained, presenting a sort of 'black box'. So, their conclusions should be taken with a pinch of salt. But recent reports by BCG and the Ellen MacArthur Foundation using this approach claim that regenerative agriculture can deliver higher profitability of between $125 and $240 per hectare, depending on the geography and production system, usually after a period of transition.

Yet, not all studies reach such a positive conclusion on profitability. As claims about regenerative agriculture have gained traction, they have been subject to greater scrutiny. A study of 16 sheep and beef farms in New Zealand in 2022 found that conventional farms were more profitable than regenerative examples because of higher production levels.[127]

In Australia, a study of lower-input grazing showed higher profitability per animal raised, but critics pointed out that profitability per hectare was lower than the best conventional operators because of lower stocking rates.[128] It is important that claims about regenerative agriculture are subject to this sort of scrutiny and that research on the topic is rigorous.

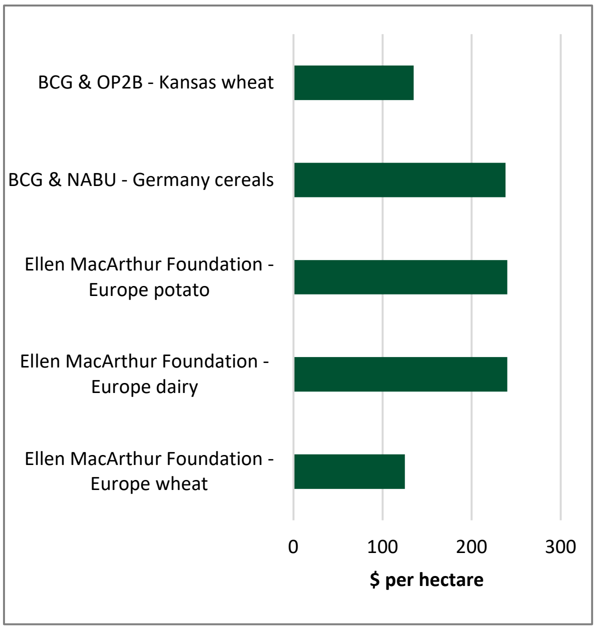
As always, it all comes down to context. Regenerative farming has the potential to be more profitable but it depends on the farmer, local markets, scale and other factors. Any

Profitability of conventional and organic grains in Northern Illinois

	Corn		Soybeans	
	Conventional	Organic	Conventional	Organic
Yield (bushels)	221	190	68	55
Price per bushel	4.50	9.00	11.50	22.50
Revenue ($)	995	1,710	782	1,238
Total non-land costs ($)	-816	-800	-494	-425
Operator and land return ($)	179	910	288	813
Land costs (rent) ($)	-318	-318	-318	-318
Farmer return ($)	**-140**	**592**	**-30**	**495**

Source: a) Conventional - University of Illinois, Farmdoc daily, January 9, 2024; b) Organic – data from farmers in SLM Partners network investment case needs to be built from the ground up based on real farm experience.

Increased profitability of regenerative agriculture: high-level studies



Source: D. Petry et al, *Cultivating farmer prosperity: Investing in Regenerative Agriculture* (BCG & OP2B, May 2023); T. Kurth et al, *The Case for Regenerative Agriculture in Germany - and Beyond* (BCG & NABU, 2023); Ellen MacArthur Foundation, *The big food redesign: Regenerating nature with the circular economy* (2021)

Resilience

A benefit of regenerative agriculture is resilience. The world will face increasing climatic volatility in the coming decades because of global warming. This will lead to more droughts, heatwaves, storms and floods. We need to design our farming systems to withstand these shocks. Farmers also face volatile input costs and commodity prices, as well as increasing social pressure because of their environmental impacts. Any farming approach that can smooth out volatility, reduce risk and deliver more consistent profitability from year to year has economic value.

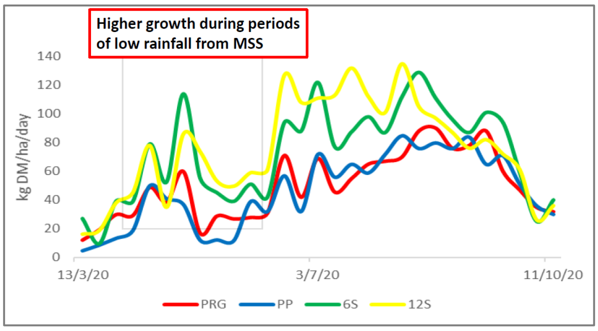
Regenerative agriculture is part of the answer. Regenerative farming systems tend to embrace a wider range of crops and livestock, providing diversification. Moreover, they rely on healthy soils and ecosystem functionality to absorb the shocks. For example, soils with more organic matter act like a sponge, soaking up rain during heavy downpours and then releasing it slowly when the landscape dries out, smoothing out the effects of extreme weather. Improved water infiltration and water holding capacity leads to more stable production.[129]

In our 2016 white paper, we provided farm-level examples from the US and Europe of how regenerative and organic practices allowed for higher yields during periods of drought and flood. Recent studies have supported this. The Soil Health Institute project that interviewed 100 farmers across 9 states in the US found that 97% of the participating farmers reported increased crop resilience to extreme weather from adopting soil health practices.[130] A report by BCG and NABU claims that regenerative practices can reduce yield losses in years marked by severe weather conditions by up to 50%.[131]

Two recent studies have used large datasets to show the link between soil health and more stable production in the US Midwest. One study looked at crop yields and crop insurance data at a county-level from 2000 and 2016 and showed that counties with higher soil organic matter were associated with greater yields, lower yield losses, and lower rates of crop insurance payouts under drought. Under severe drought, every increase of 1% soil organic matter was associated with a yield increase of 32.7 bushels per acre for corn.[132] Turning to floods rather than droughts, the ag-data company Dagan used satellite imagery to assess the susceptibility of farmland to flooding during the 2018-2019 winter/spring season, when millions of acres were prevented from planting. They found that fields that were successfully planted in spring of 2019 showed higher average number of years with conservation tillage, no-till practices, and winter cover crops. This indicates that conservation practices can increase resilience to flooding.[133]

In grazing systems, diverse swards and healthy pastures help sustain production during times of low rainfall. Evidence comes from Dowth in Co. Meath, Ireland, a 180-hectare research farm that raises beef cattle and sheep, part of the global network of Lighthouse Farms that are leaders in sustainability. They trialled multi-species swards as an alternative to highly fertilised perennial rye grass monocultures or permanent pasture. They found that multi-species swards required 60% less nitrogen that perennial ryegrass (reducing nutrient run-off), produced 40% more herbage (measured as dry matter production), and led to higher daily weight gains for beef cattle and heavier, healthier lambs, while reducing GHG emissions by 26%. But these diverse swards were also more resilient to drought. They grew better during dry summer months compared to perennial rye grass or permanent pasture. As climate change leads to longer dry spells in summer, this will be increasingly important in Ireland.[134]

Forage growth on Dowth, Co. Meath, Ireland



Source: Heartland Project, *Heartland: One Health from Soil to Society*, Presentation

Regenerative agriculture can strengthen resilience to climate change and offer a path towards climate adaptation. But it can also provide more social resilience. Societies and governments are increasingly concerned about the negative environmental externalities caused by the food system. Regulations are being tightened about what farmers can and cannot do. For example, the European Union's Farm to Fork Strategy, part of its broader Green New Deal, sets out an ambitious plan to transform European agriculture over the next 30 years. Farmers will need to reduce use of chemical pesticides by 50%, synthetic fertilisers by 20%, antimicrobials for animals by 50% and overall GHG emissions by 55%. There is a goal to reach 25% of agricultural land under organic certification by 2030.[135] If implemented, this will change how farming is practised in Europe. Already European farmers have to grapple with the prohibition of more pesticides each year, shrinking their chemical toolboxes, which forces them to try new approaches. Regenerative agriculture is one step ahead, entirely consistent with the EU policy goals and less exposed to regulatory pressure.

Even if regulators do not take action, food buyers may force change in the agricultural system. Responding to consumer pressure, food companies are pushing sustainability frameworks back through their supply chains, asking farmers to report on their carbon footprint and other environmental impacts, and enforcing higher standards. Instead of offering meaningful price premiums for regenerative products (a carrot), they may force their suppliers to adopt regenerative practices in order to access their markets (a stick). The risk for conventional farming systems that are perceived as polluting and unhealthy is that their products will be relegated to lower value commodity markets. In contrast, regenerative farmers are at the frontier of sustainability, maximising their access to high value markets. As a result, regenerative agriculture is more future-proof.

How to invest

There are many ways that investors can take advantage of this opportunity and accelerate the transition to regenerative agriculture. Each strategy has a different risk/return profile and can play a different role in a balanced investment portfolio.

Mapping the investment landscape

The diagram below shows the key parts of the food value chain and the investment asset classes that are most relevant – venture, private equity, listed equities, real assets and credit. Investors can invest in the food value chain via one or more of these asset classes, each of which has a different risk/return profile.

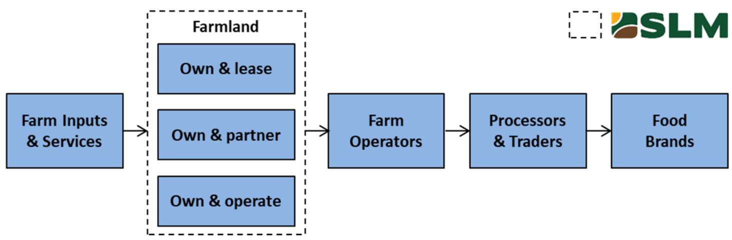
Farm Inputs & Services

Over the last few years, dozens of start-ups have been established to develop technologies, products and services that can be sold to farmers to facilitate a transition to regenerative practices. These include biological fertilisers and soil amendments, biological seed coatings, new seeds, new farm machinery, virtual fencing, precision farming technologies, soil and climate sensors, satellite imagery analysis, farm management software, and carbon project developers to name just a few. Cash-strapped farmers are often reluctant to spend money on unproven products and services, and one of the principles of regenerative agriculture is to minimise spend on external inputs, which creates a challenge for some business models. Nonetheless, some of these companies can play an important role in supporting regenerative agriculture. Early-stage companies are ripe for Venture investing, while more developed companies can attract Private Equity funding, and the largest become Listed Equities or are acquired by publicly listed companies.

Farmland

Investors can have the most direct impact on how land is managed by investing in farmland itself, either via funds or separately managed accounts. There is where we focus our efforts at SLM Partners. Ownership of the land allows

Investing in the food value chain



Investment asset classes

	Farm Inputs & Services	Farmland	Farm Operators	Processors & Traders	Food Brands
Venture	✓				✓
Private Equity	✓		✓	✓	✓
Listed Equities	✓			✓	✓
Real Assets		✓	✓		
Credit			✓	✓	✓

investors, via their managers, to specify the type of regenerative farming practices that will be used. This can be done by operating the land directly (via hired farm managers), by partnering with expert local farmers through joint ventures or long-term management contracts, or by leasing the land to carefully-chosen farmers. Farmland ownership also allows investors to benefit from the full value of the improvement to the land caused by regenerative farming, as well as any sector-wide appreciation in land values. Farmland can form part of a Real Assets allocation in an investor portfolio. The benefits of farmland as a real asset are explored further below.

Farm Operators

Funding regenerative farmers directly is often not easy for investors. The agriculture sector, even in the most developed countries, is dominated by family farming operations. The vast majority do not want, and are not set up to receive, external equity investment. They are largely funded by debt. This creates an opportunity for Credit strategies that can help finance multi-year transitions to regenerative agriculture. There are a small number of larger farming operations – family-run but with professional corporate structures – that are willing to take outside investment, and this opens up an opportunity for Private Equity. Some of these are vertically-integrated operations that own farmland, which gives investors some exposure to Real Assets too. These vertically-integrated operations tend to be found in high value specialty and permanent crops, and they lean more towards the risk-return profile of Private Equity. Few if any farm operators are publicly listed, apart from isolated examples in South America and Australia.

Processors & Traders

A small number of companies are emerging to create regenerative supply chains that can link farmers with food buyers. They aggregate supply from multiple farmers, carry out some degree of processing (e.g. olive oil mills, grain mills, abattoirs), and sell to food companies, offering traceability and differentiation from standard commodities. Some large, established processors and traders are also trying to shift their supply chains towards regenerative agriculture. These companies can benefit from Credit strategies or Private Equity investment, while the largest may be Listed Equities.

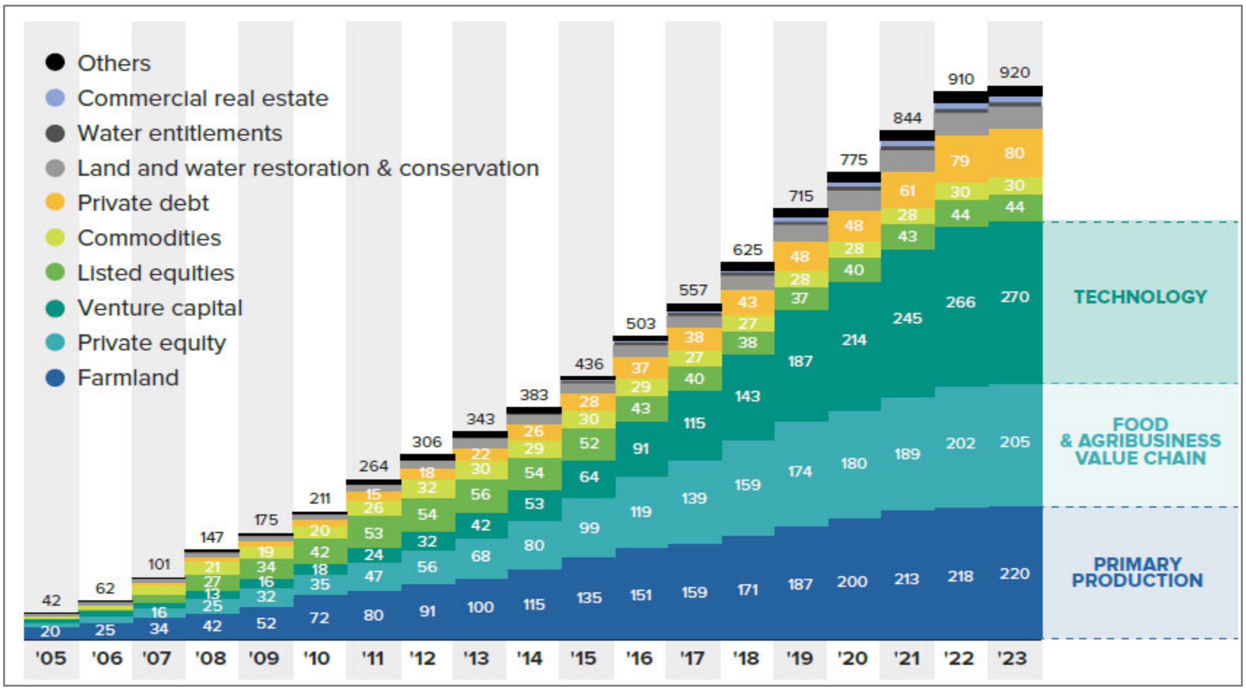
Food Brands

Consumer-facing companies are creating narratives and brands around regenerative agriculture to tap into growing interest in food sustainability. This includes Consumer Packaged Goods (CPG) companies, restaurant and food service companies, and food delivery companies. They can play an important role in scaling up regenerative agriculture by providing strong markets and price premiums for farmers who adopt regenerative practices. Early-stage companies are ripe for Venture investing, while more developed companies can attract Private Equity or Credit funding, and the largest become Listed Equities or are acquired by publicly listed companies.

Investor allocations to agriculture

According to Valoral Advisors, there has been a substantial increase in the number of funds that specialise in food and agriculture since 2008. See chart below. This has been driven by funds that invest in Farmland or Real Assets (5.2x increase), Private Equity (8.2x increase) and Venture (20.7x increase). In contrast, there has been limited growth in the number of specialised funds that invest in this sector via Listed Equities (1.6x increase) or Commodities (1.4x), probably because these asset classes provide weaker exposure to the fundamentals of agricultural production and, in the case of Commodities, have under-performed.[136]

Number of active funs specialised in food and agriculture by main strategy



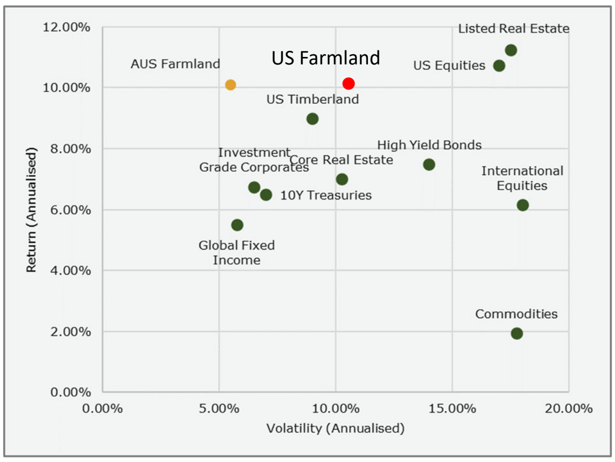
Source: Valoral Advisors

The benefits of farmland as a real asset

In our 2016 white paper, we identified an increasing interest among investors in farmland as an asset class since the spike in food prices around 2007-08. This trend has continued. More and more institutional investors and family offices are making allocations to farmland as part of their Real Assets portfolios (alongside forestry, real estate, energy and infrastructure). Data from Valoral Advisors indicates that there were 220 funds actively investing in farmland in 2023. This under-estimates investment activity, as many investors now invest via separately managed accounts, which are not captured in these figures.

Farmland has performed well against other assets classes. The best data is available in the US. The NCREIF Farmland Index in the USA has outperformed stocks and bonds over the past ten, twenty, thirty and forty years, with lower volatility. Between 1990 and 2020 the index delivered an annualised return of 10.5%, with a Standard Deviation of just 7%. Australian farmland also delivered annualised returns in excess of 10% over the same period, with low volatility.

Returns and volatility of US and Australian farmland



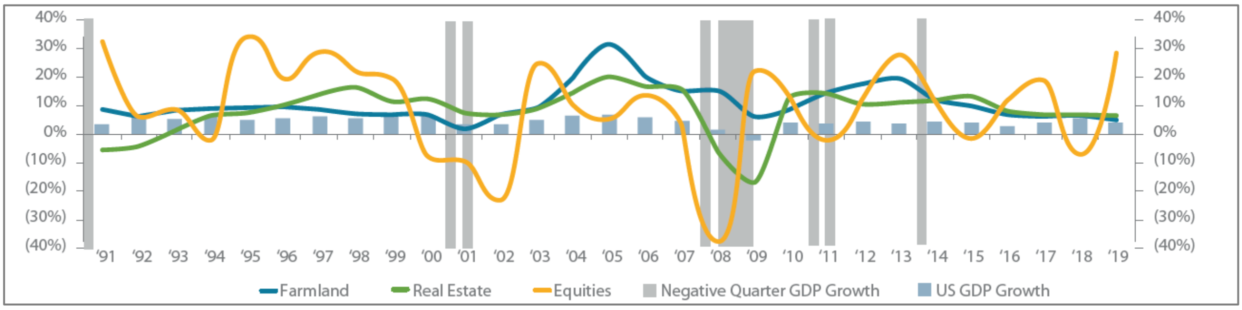
Source: AUS Farmland: ABARES – Historical data set for top 25% of Australian farm, 1993-2003; US Farmland – NCREIF Farmland Index, 1990-2020; Listed Real Estate: FTSE NAREIT All Equity REITs; Core Real Estate: NCREIF NFI-ODCE; Timberland: NCREIF Timber, 1990-2020; Investment Grade Corporates: ICE BofA US Corporate Index; 10 Year Treasuries: ICE BofA U.S. Treasury 7-10 Year; High Yield Bonds: Bloomberg Barclays U.S. Corporate High Yield 2% Issuer Capped Index. Values from start of data 31 Dec 1992.; U.S. Equities: S&P 500; International Equities: MSCI EAFE; Global Fixed Income: BBG Global Agg.; Commodities: BBG Commodity. Values from start of data 31 Dec 1992. It is not possible to invest in an index. Performance for indices does not reflect investment fees or transactions costs

Farmland has a number of characteristics that make it attractive to investors. It is a real asset that offers downside protection and can generate annual income, either in the form of rents or profits from farm operations. The returns from farmland are historically uncorrelated or negatively correlated with equity and bond markets, providing diversification. And these investments offer a natural hedge against inflation, as food prices and farmland prices tend to go up during inflationary periods. Farmland also has embedded optionality value, with the possibility that it can be developed for renewable energy projects or other uses in the future.

Farmland as an asset class is resilient to fluctuations in economic and financial market cycles. A detailed analysis by Stepstone on the attractiveness of farmland for institutional investment showed how farmland was able to better preserve investor capital through recessions relative to other sectors.[137] The diversification benefits of farmland have been evident during the financial turmoil of the past 2 years. Rampant inflation, economic slowdown and interest rate hikes combined to pummel public equity and bond markets, which fell by 25-30% from their peak by the end of 2022. In contrast, farmland values have risen strongly in key geographies such as the USA, Australia and many parts of Europe. For example, average cropland prices in the USA rose by almost 23% between 2020 and 2022, while the average price for broadacre farms in Australia surged by 93% between 2020 and 2023. Farmland fulfilled its function by providing stability during a period of financial volatility.

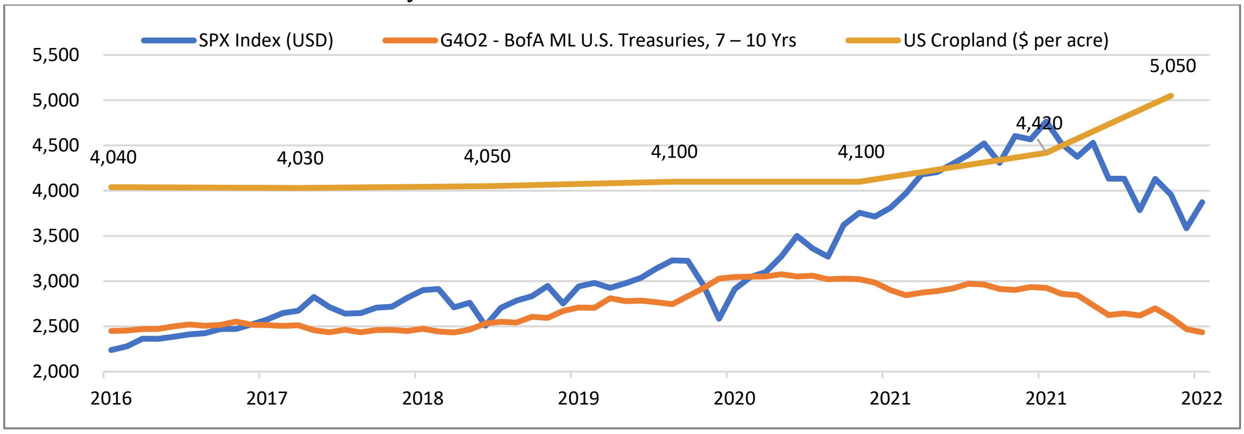
There are different ways that investors can gain exposure to farmland as an asset class: these include lease strategies, farm operating

Capital preservation from farmland through market cycles



Source: Stepstone, Agriculture: Ripe for Institutional Investment (2022). Bloomberg, December 31, 2019. Note: Farmland =NCREIF Farmland Index; Real Estate = NCREIF Real Estate Index; Equities = Russell 3000 Index.

Farmland has been an oasis of stability in recent times



Source: USDA – NASS, as of Augusto 2022 Cropland Values ($ per acre), Bloomberg SPX and G402 - BofA ML U.S. Treasuries, 7 – 10 Yrs

strategies and vertically-integrated strategies. The choice depends on an investor's risk-return objectives, need for predictable income, tolerance for downstream exposure and need for real asset backing. Stepstone provide a helpful decision tree that gives an illustration of the types of gross returns that can be achieved (in a developed market context), including a comparison with Private Equity and Venture strategies. See the *Agriculture investment decision tree* here below.

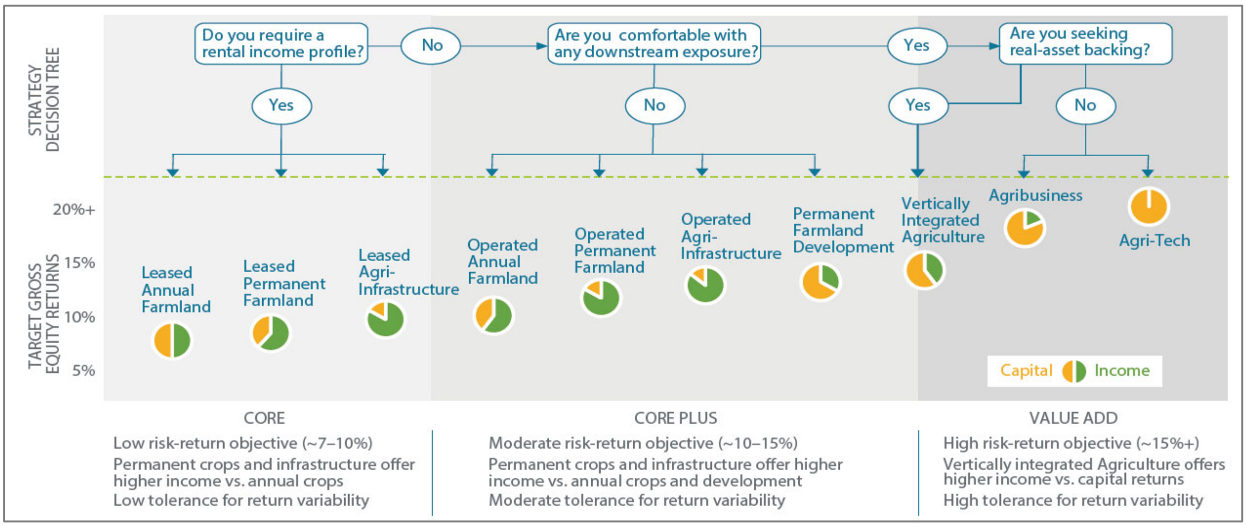
Regenerative Real Assets

These financial characteristics are attracting more investors to allocate to farmland in general. But investing in farmland that is managed regeneratively – what we call "Regenerative Real Assets" – has added benefits and can provide Alpha for investors. As we have seen, it can generate higher profitability from operations, some of which can flow back to investors. It can position investors to take advantage of new environmental markets, such as for carbon or biodiversity. Regenerative management should enhance the soil quality and the natural resource base, which can support higher capital values over the long-term. In our experience, in the right context, Regenerative Real Assets can deliver an internal rate of return (IRR) that is 1-3% higher than conventional farmland investing. Regenerative agriculture also mitigates a number of social, environmental and economic risks and provides resilience to climate change and natural capital loss.

Investing in regenerative farmland can also help investors deliver on their commitments on climate change, biodiversity and natural capital.

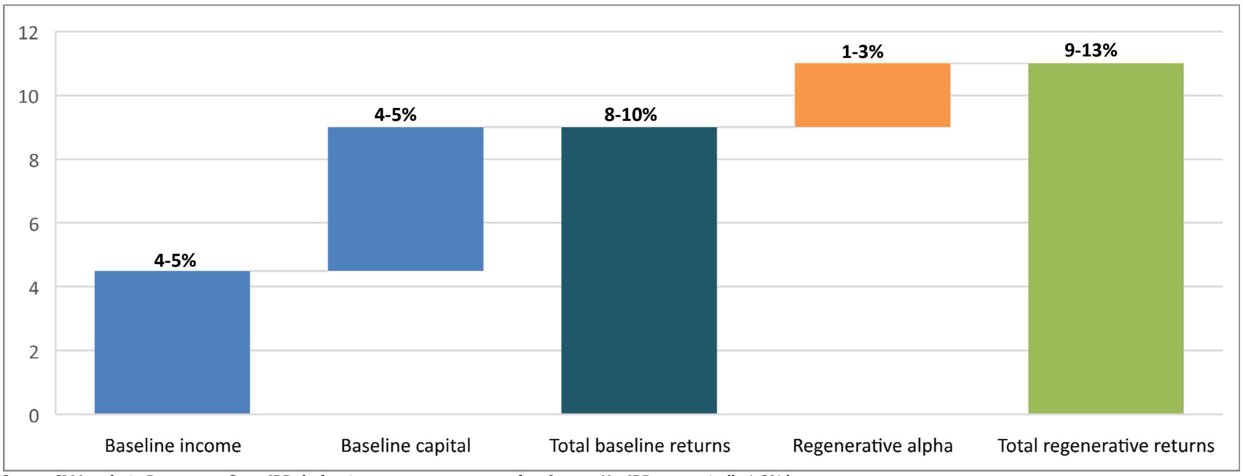
Following the Paris Agreement on climate change, many institutional investors are making commitments to Net Zero by 2050. They are seeking to align their portfolios and reporting with the Science-Based Targets Initiative (SBTi)[138] and the Task Force on Climate-related Financial Disclosure (TCFD).[139] Following the agreement of the Kunming-Montreal Global Biodiversity Framework (GBF) and the work of the Task Force on Nature-Related Financial Disclosure (TNFD),[140] investors are also measuring their broader dependencies and impacts on nature and seeking to understand and manage these risks. Regenerative Real Assets sit squarely within a Natural Capital allocation, in a way that many conventional farmland or timberland strategies do not.

Agriculture investment decision tree



Source: Stepstone, *Agriculture: ripe for institutional investment* (Sep 2020)

Regenerative Alpha – illustrative farm-level investment returns



Source: SLM analysis. Returns are Gross IRRs before investment management fees & costs. Net IRRs are typically 1-2% lower.

Overcoming challenges

Nonetheless, there are challenges to investing in regenerative farmland: a scarcity of regenerative farmers, scale limitations, overvalued land assets and tough farming economics. We have grappled with all of them over the last a decade and place a keen focus on each of them when developing new strategies.

Partnering with the right farmers

If we have learnt one thing over the last decade it is this: land acquisition is relatively easy but farming is really hard. Regenerative farming is especially hard, as it involves a deeper understanding of soil biology, crop and animal interactions, ecosystem functionality and, in some cases, specialist markets. Experienced regenerative farmers, who are willing and able to work with investors and investment managers, are a scarce commodity. This is why we now develop all our strategies by starting with the farmer first, and only then think about acquiring land. Putting the right operating partner in place, with aligned incentives, is critical to the success of any regenerative farmland investment. This can be achieved through profit-sharing leases, management agreements that share risk and rewards, or joint venture structures, all with a suitably long time-horizon.

SLM farm team in Australia

Scale limitations

Institutional investors and managers sometimes come to this theme looking to deploy billions of dollars quickly, as this is what they do for infrastructure, private equity or other asset classes. But farmland markets are fragmented in most parts of the world, limiting investment size. Moreover, there is a limit to how quickly regenerative farmers can scale their operations without losing control and effectiveness. And it takes time for new farmers to absorb the knowledge and adopt regenerative practices. Even if the academic evidence is there, farmers learn best from one another, often by looking over the fence, which can be a slow process. As a result, there is often a trade-off between scale and both environmental impact and financial return. Our experience is that the most impactful strategies, and the highest financial returns, are often delivered by strategies that are measured in the hundreds of millions, rather than billions, of dollars. Over time, scale can be achieved, but going too fast can lead to disappointment. Managers, investors and farmers must have honest conversations about what can be achieved and when.

Overvalued land assets

Farmland values in many parts of the world have appreciated strongly over the last 10-15 years, as we saw earlier. In a way, farmland as an asset class has been a victim of its own success, attracting inflows of capital from investors seeking a safe haven and income yield during a period of extraordinary financial conditions. This has pushed discount rates and income yields down in the main investable geographies. As interest rates climb, the return on farmland assets does not look as favourable as before. Investors and managers will need to maintain discipline when investing. There will be more pressure to develop value-add strategies that provide some form of Alpha. Regenerative agriculture can be one such value-add strategy. As a more profitable and less risky form of agriculture, it can deliver acceptable yields to investors in a time of elevated asset values. Indeed, it may be that investors only want to allocate to strategies with the ‘Regenerative Edge’ because the financial returns of conventional farming are unappealing.

Understanding farming economics

Even with the most regenerative practices, there are many farming sectors that are not attractive for investment because they face unfavourable market structures. Farming is a tough business. Demand for products can change (e.g. apple varieties going in and out of fashion) leaving agricultural assets stranded. If too many farmers chase an opportunity, markets can become over-supplied, leading to a collapse in prices. Farmers are often compelled to keep producing and selling into these markets in an attempt to recoup fixed costs and service debts, further depressing prices. In many cases, large numbers of farmers supply agricultural commodity markets that are dominated by a small number of large processors or retailers with disproportionate market power. Farmers are usually price-takers, and margins along the value chain are not always fairly distributed. Farmers can also face difficulties in accessing markets because of distance, poor logistical infrastructure or tariff barriers. Or they can face competition from other countries with lower costs of production. If investors seek a market-rate return, in-depth market research is required to understand market structures and macro trends and to pick farming sectors that are well-positioned to grow. Less favourable sectors may only be suitable for impact-focused concessional capital, and more favourable sectors need to be scaled responsibly to avoid economic harm to incumbent producers.

Conclusion

Regenerative agriculture has great potential. It can address many of the negative social and environmental impacts associated with our food systems, while restoring the productive capacity of ecosystems, building resilience and growing healthier food. Regenerative agriculture can also improve profitability at the farm-level, which makes it an attractive investment opportunity. But there are limitations to what agriculture can deliver for investors, whether regenerative or not. A realistic attitude to rates of return and scale is needed, and investment strategies must be built on rigorous analysis of market dynamics and careful selection of farmer partners – the scarcest commodity of all.

We hope that investors can navigate between the Scylla and Charybdis of hype and greenwashing that surrounds this topic. If they can avoid these perils, and get to the other side, their capital can play an important role in accelerating the transition to a regenerative future.

Further reading

If you want to learn more about regenerative agriculture, the following resources are a good way into the topic.

Books

Dan Barber, *The third plate: field notes on the future of food* (2015) – an award-winning 'farm to table' chef shows how regenerative agriculture grows better food while restoring land health

Gabe Brown, *Dirt to soil: one family's journey into regenerative agriculture* (2018) – the story of one of the leading farmers in the US regenerative agriculture movement

Charles Massy, *Call of the reed warbler: a new agriculture – a new earth* (2017) – contains profiles of innovative farmers in Australia along with a scientific and philosophical analysis of regenerative agriculture

David Montgomery, *Growing a revolution: bringing our soil back to life* (2017) – good collection of case studies of regenerative farmers, mostly in the US

David Montgomery, W*hat your food ate: how to restore our land and reclaim our health* (2022) – groundbreaking work on links between health soil, healthy food and healthy people

Academic papers & reports

EASAC, *Regenerative agriculture in Europe*, EASAC policy report 44 (Apr 2022)

FOLU, *Aligning regenerative agricultural practices with outcomes to deliver for people, nature and climate* (Jan 2023)

K.E. Giller et al, 'Regenerative agriculture: an agronomic perspective', *Outlook on Agriculture* 50 (1), 13–25. (2021)

R. Khangura et al, 'Regenerative agriculture—a literature review on the practices and mechanisms used to improve soil health', *Sustainability*, 15, 2338 (2023)

T. O'Donoghue et al, 'Regenerative agriculture and its potential to improve farmscape function', *Sustainability*, 14 (2022)

C. N. Merfield, *An analysis and overview of regenerative agriculture*, The BHU Future Farming Centre, Report 2-2019 (2019)

P. Newton, 'What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes', *Front. Sustain. Food Syst.*, 4 (2020)

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[4] See Ch. 9, Charles Massy, *Call of the reed warbler* (2017)
[5] *Science*, 14 Aug 2015
[6] C.M. Kallenbach et al, 'Microbial physiology and necromass regulate agricultural soil carbon accumulation', *Soil Biology & Biochemistry*, 91 (2015). See also EASAC, *Regenerative agriculture in Europe*, EASAC policy report 44 (Apr 2022)
[7] C.N. Merfield, *An analysis and overview of regenerative agriculture*, The BHU Future Farming Centre, Report 2-2019 (2019)
[8] Mercaris. Data is for field crops.
[9] FiBL/IFOAM, *The world of organic agriculture statistics and emerging trends 2023*
[10] See his excellent book *Dirt to soil: one family's journey into regenerative agriculture* (2018)
[11] C.N. Merfield, *An analysis and overview of regenerative agriculture*, The BHU Future Farming Centre, Report 2-2019 (2019)
[12] N. Gomez-Casanovas et al, 'A review of transformative strategies for climate mitigation by grasslands', *Science of the Total Environment,* 799 (2021)
[13] See the Savory Institute website: http://savory.global/
[14] For a general review see L. Delaby, 'Pasture-based dairy systems in temperate lowlands: challenges and opportunities for the future', *Front. Sustain. Food Syst.*, Vol 4 (2020) & D. Jaramillo, 'Enhancing the sustainability of temperate pasture systems through more diverse swards', *Agronomy*, 11(10) (2021). The Irish government research agency for agricultural, Teagasc, has finally started to promote the benefits of this system. See https://www.teagasc.ie/environment/climate-change--air-quality/signpost-programme/research-updates/multi-species-swards/.
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